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1908.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK

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1908

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GEORGE A. TABER, Chairman
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IN CONTINUATION OF THE POLICY ADOPTED FOR THE PROCEDINGS OF THE PREVIOUS YEAR, THIS VOLUME, AS FAR AS POSSIBLE, HAS BEEN PRINTED IN ACCORDANCE WITH THE RULES FOR SPELLING RECOMMENDED BY THE "SIMPLIFIED SPELLING BOARD," OF No. 1 MADISON AVENUE, NEW YORK CITY.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK

Paper No. 38

PRESENTED FEBRUARY 26, 1908.

THE PROPOSED FILTRATION OF THE CROTON WATER SUPPLY OF NEW YORK CITY.

BY MR. WILLIAM B. FULLER,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEORGE W. FULLER, BERNARD M. WAGNER, GEORGE A. JOHNSON,
RICHARD D. CHASE, EDWARD WEGMANN, ALFRED D. FLINN,
HERMAN A. RUGE, ARTHUR S. TUTTLE, ROBERT
RIDGWAY, AND THE AUTHOR.

HISTORICAL.

The Croton watershed has furnisht practically the entire supply of water to the City of New York, Boros of Manhattan and The Bronx for sixty-six years, or since the year 1842, at which date what is now known as the Old Croton Aqueduct was first put into service, bringing water to the City from Croton Lake, then a small reservoir of 160 million gallons capacity formed by a small overfall dam across the Croton River.

It was believed at the time of the bilding of the Old Croton Aqueduct that its full capacity of 90 million gallons per day would not be needed for at least a century and that New York's water question was solved for practically all time, but so marvelous was the growth of population that in 1886, that is, within forty-four years, the aqueduct was unable to furnish the required amount of water and in 1890 the New Croton Aqueduct, having a capacity of 300 million gallons per day, or more than three times that of the Old, was put into service.

---

* Consulting Civil Engineer, 170 Broadway, New York.

In the meantime, altho the area of the Croton watershed is approximately 360 sq. miles, the continually increasing demand for water made it evident that the storage afforded by the Old Croton reservoir was insufficient to furnish the required supply during the months of low flow of the Croton River, and in 1874, by the bilding of Boyd's Corner dam and reservoir, was begun that system of storage reservoirs distributed over the watershed, which has brought the total storage to a present capacity of 72 000 million gallons, sufficient in itself to supply the City for 240 days.

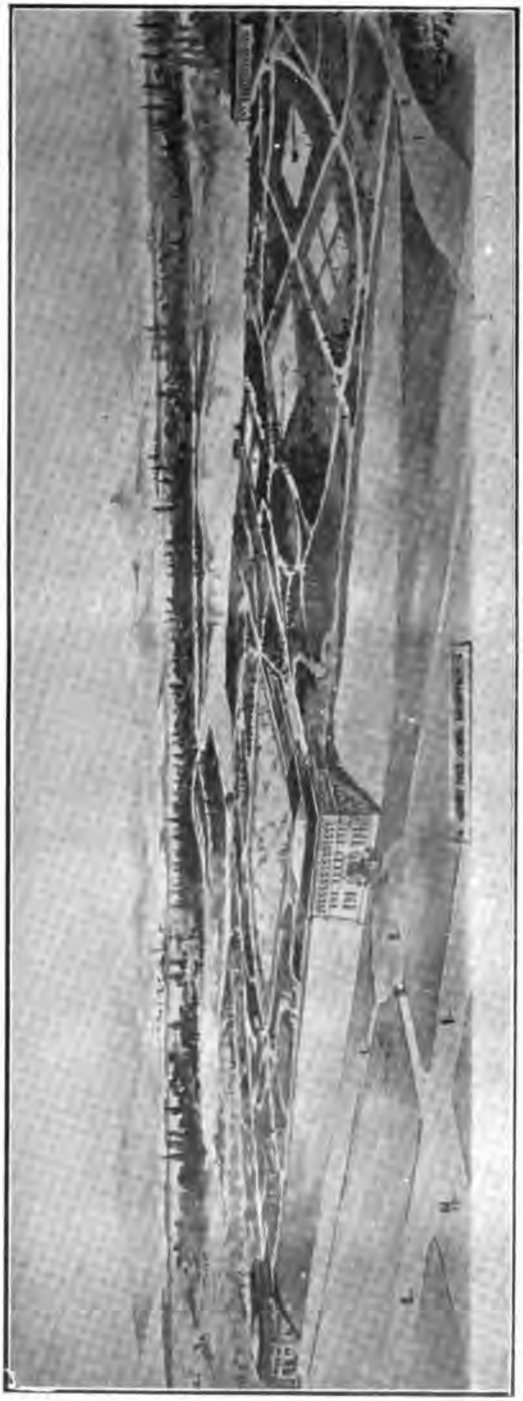
These changes, made necessary by the continual demand for more water, have also resulted in important changes in the water itself. The Croton, from a flashy stream delivering alternately very muddy and very clear water, has been gradually changed as the storage reservoirs have gone into service, and in them the heavier particles of mud have settled out, but often the finer particles have been distributed thruout the supply for long periods, imparting a certain cloudiness objectionable from an esthetic point of view.

The color of the water due to vegetable stain has always been objectionable, and an increase in storage, by offering a longer time for the bleaching effect of the sun, would have ordinarily reduced it to a noticeable degree, but the increast shallow flowage, by furnishing more color-producing material, has offset any gain due to the storage. The increasing shallow flowage has also had the effect of greatly increasing the algæ, micro-organisms and amorphous matter present in the water, imparting tastes and odors. The constantly increasing draft on the storage reservoirs results in drawing down these reservoirs and exposing the mud flats to plant growth more and more each year, and this growth is flooded in the fall, producing bad tastes, odors and increase of color.

The attractivness of the watershed to suburban residents due to its healthfulness, scenic advantages and accessibility to the City, has materially increast its population and consequently increast the danger of polluting the supply with typhoid fever and kindred diseases.

It has been repeatedly stated in the public press by Thomas Darlington, M. D., President of the New York City Department of Health, that typhoid fever, due to the City water supply, is gradually increasing year after year, and this statement is borne out by

PLATE 1.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FULLER ON PROPOSED FILTRATION
OF CROTON WATER SUPPLY.



Perspective View of Proposed Plant when Completed.

the observations and yearly reports of the Chemical and Bacteriological Division of the Department of Water Supply, Gas and Electricity.

From a combination of all of the above-cited causes, filtration of the Croton water supply has been a live topic of discussion for many years, and has been reported on and recommended from time to time by many distinguisht engineers.

The first definit action, however, looking to an early construction of a filter plant, was taken on May 11, 1906, on the recommendation of Mr. I. M. de Varona, Chief Engineer of the Department of Water Supply, Gas and Electricity, by the Board of Estimate granting an appropriation, to examin in detail and select the best site for a filter plant for the Croton water supply, and to prepare plans and specifications for the proper execution of the work. This work was placed in charge of the writer, as Engineer in Charge of Filtration, under the general supervision of Mr. I. M. de Varona, Chief Engineer of the Department of Water Supply, Gas and Electricity, and with Mr. Rudolph Hering and Mr. George W. Fuller as Consulting Engineers.

STUDY OF SITES.

Water is brought from the Croton watershed to the City from an inlet gate-house on New Croton Lake by two aqueducts; the Old Croton Aqueduct, having a diameter of 7½ ft. and a capacity when flowing full of 90 million gallons per day, and the New Croton Aqueduct, with a diameter of 13½ ft. and a capacity when flowing full of 300 million gallons per day. The Old Aqueduct follows along the contours of the hillside as a cut and cover aqueduct, and has a length of 30 miles between Croton Lake and Jerome Park Reservoir, while the New Aqueduct cuts across country by deep tunneling thru the hills, and has only a length of 25 miles between the same points. It was evident that the filter plant must be located so as to utilize the capacity of both aqueducts and this narrowed the selection of sites to points where the two aqueducts were accessible from the same site. The Burr-Hering-Freeman Commission in 1903 selected two such sites; one at Goulds Meadows, the other at Elmsford, both situated about 3 miles southeast of Tarrytown, and about 12 miles below Croton Lake intake; and made provisional locations and estimates for filters thereon, basing their designs on filtration at a rate of 3 million gallons per acre per day. Careful consideration was given to these studies. Two other sites, one at Dunwoodie, about 21 miles from Croton Lake intake, and the other at Jerome Park Reservoir, also presented favorable conditions for investigation, the latter having been first suggested by Mr. I. M. de Varona about a year previously.

Careful estimates of cost were made for filters at all four sites and, assuming that a covered reservoir of 135 acres would be bilt under any of the plans, there was found to be a great saving in cost by utilizing the site at Jerome Park Reservoir, placing the filters as a second story, directly over the covered clear water reservoir. The most recent estimates show that of the $8 500 000 askt for the completion of the Jerome Park Reservoir, and bilding of filters, only $3 500 000 is chargeable to filtration, a saving of over $1 000 000 over the cheapest of the other sites proposed, not including the cost of land at these sites, nor the difficulties and delays in procuring the sites themselves, owing to an Act of the Legislature still in force, preventing the City from acquiring any lands by condemnation procedings in Westchester and Putnam Counties.

Another consideration, besides those of saving in cost and delays of construction, adding weight to the selection of Jerome Park Reservoir as the best site for the filtration plant, was the nearness of the site to the City, within the present City limits, thus allowing of the use of the covered surface as a park, and by easy accessibility and constant presence of visitors insuring more efficient and economical supervision, operation and maintenance. Still more important, the location of the filter at the lower end of the aqueducts within the City and close to where the supply is taken into the distribution system, was a great insurance against any accidental pollution of the water between the time of filtration and use by the consumer.

Rate of Filtration.

Croton water, owing to the large impounding reservoirs and the great length of the aqueducts bringing the water to the filters, is distinctly easier to filter than most other supplies now being filtered in this country, except, perhaps, the supplies at Reading, Pa., New

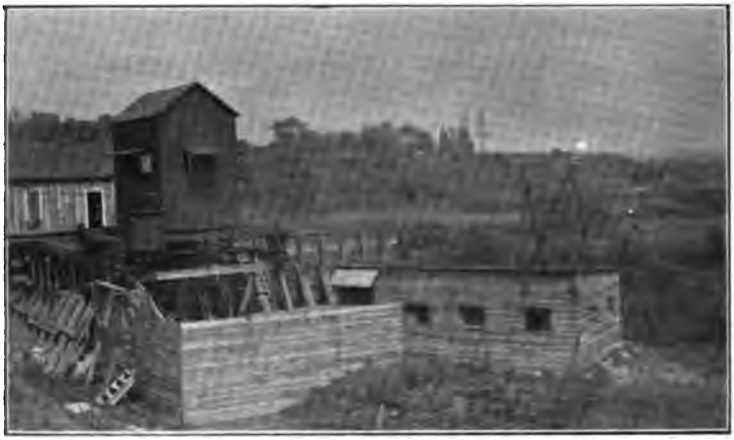


FIG. 1.—EXPERIMENTAL STATION, SHOWING BLAISDELL WASHING MACHINE.

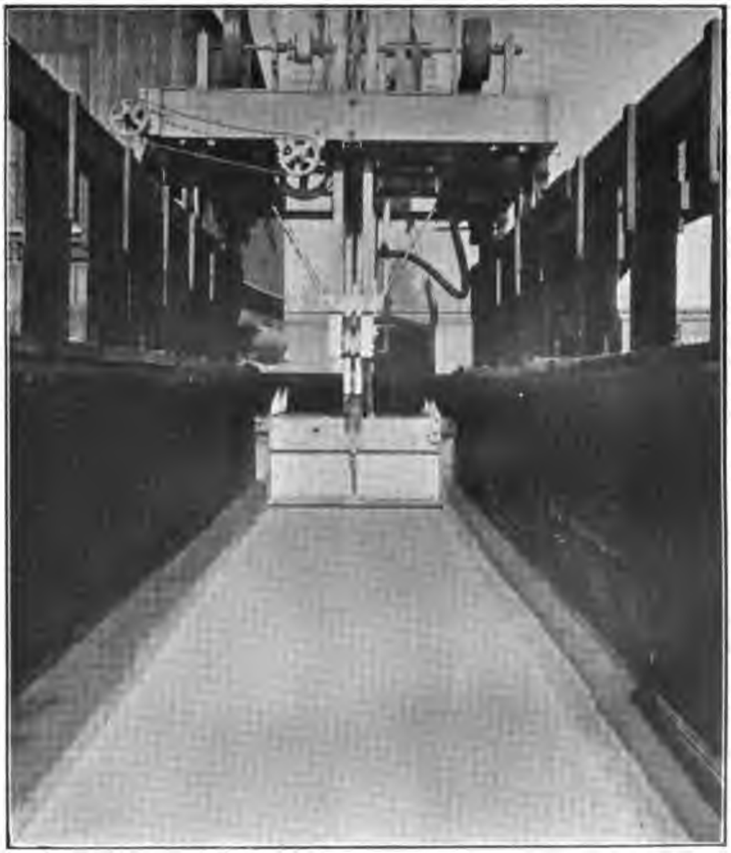


FIG. 2.—VIEW OF FILTER WITH WATER DRAWN OFF, SHOWING CLEANED SURFACE OF SAND AFTER PASSAGE OF WASHING MACHINE WITH DIRTY SAND ON EACH SIDE.

Haven, Conn., and a few other small plants. Most filter plants treating water drawn without much storage from rivers containing considerable sewage, silt and clay, have been operated at a rate of two and one-half to three million gallons per acre per day, but carefully conducted investigations at the Lawrence Experimental Station of the Massachusetts State Board of Health, and at Cincinnati and New Orleans, and practical experiences at Reading, show that double these rates are entirely feasible for water less impure and containing comparativly small amounts of finely divided clay. In fact, the investigations above mentioned, combined with experimental experience at Springfield, Mass., and the successful filters at Zurich, Switzerland, show that a rate of 10 million gal. per acre per day is feasible, provided the water has had a proper preparatory treatment.

Obviously the rate of filtration has a very great bearing on the construction cost, amounting in this case to a saving of over one-half a million dollars for each increase of the rate by 1 million gallons per acre daily, and very careful consideration was given to this question by the Consulting Engineers and all members of the staff.

Lost Time During Cleaning.

Intimately connected with any high rates of filtration is the question of the time the filter is to be held out of service for cleaning. The rate of filtration does not materially affect the quantity of water filtered between cleanings of the sand surface, or the time required for a single cleaning, so that a higher rate means that the filter is out of service for a much greater portion of the time.

The methods of cleaning slow sand filters in use by all the plants now in operation, involve the drawing off of the water over the sand surface, the scraping up and transporting outside of the filter the dirty top layer of sand, the refilling of the filter from below, and the operating of the filter at low rates for several days until the formation of a sufficient schmutzdecke, the total equivalent time out of service being from three to five days. Assuming 60 million gal. of water filtered per acre between cleanings, a rate of filtration of 3 million gal. per acre daily and three days for cleaning, the filter would be out of service 13% of the time, and 15% reserve area would be required to maintain the nominal rate. Assuming as before, but with a rate of filtration of 10 million gal. per day, and the time out of service becomes 33%, and 50% reserve area would be required to maintain the nominal rate.

That is, under circumstances as assumed above, increasing the rate three and one-third times reduces the area of filters only two and one-half times. For the project under consideration, a reserve area of 50% amounted to about two million dollars, and caused a very careful study of improved methods of cleaning filters and reducing the time out of service.

EXPERIMENTAL STATION.

In view of the great interests involved as outlined above, it was decided to establish an experimental filter where the results of using high rates and new methods of cleaning could be carefully observed on Croton water. Accordingly two filters, each having an area of one-hundredth of an acre, and a complete laboratory for chemical and biological analyses, were bilt, and put in charge of trained assistants. (See Plate 2, Fig. 1.)

The filtering medium consisted of about 26 in. of Cowe Bay sand, having an effectiv size of about 0.21 mm., and a uniformity coefficient of 2.6, which was later changed to an effectiv size of about 0.34 mm., and a uniformity coefficient of about 1.8. The sand layer is supported by four layers of graded gravel of an aggregate depth of 16 in.

These experimental filters have now been in operation nearly a year, and have clearly demonstrated that Croton water can be properly purified at a rate of 10 million gal. per acre daily, and have also demonstrated two new methods of cleaning the dirty sand of the filters, either of which greatly decreases the time out of service between cleanings over the methods now universally in use on slow sand filters.

BACTERIAL RESULTS.

Separate runs have been made on the experimental filters at a 10 million rate or higher, and all, both winter and summer, have given satisfactory bacterial purification, always below 100 per c.c. after two hours from starting, and generally below 20 per c.c. Several runs have also been made at low rates, but the purification

PLATE 3.
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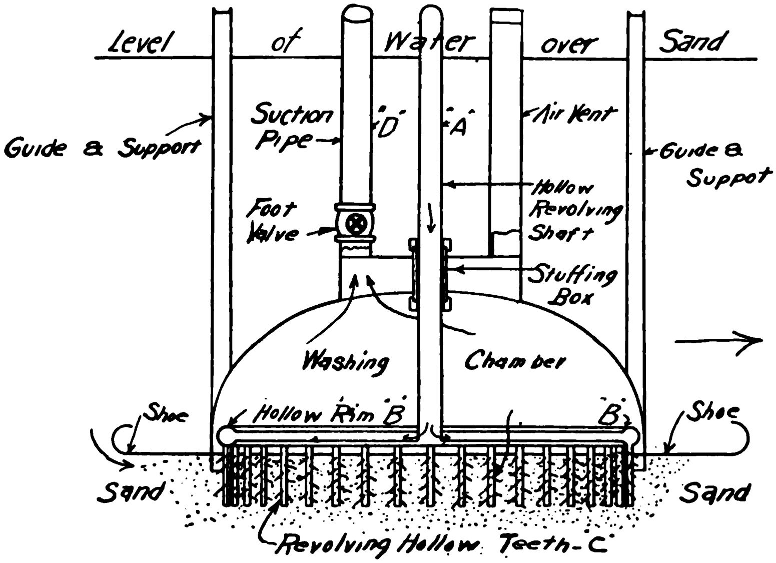

FIG. 1.—SKETCH SHOWING WASHING CHAMBER OF BLAISDELL FILTER SAND WASHING MACHINE.

Operation—The chamber being slowly moved ahead sliding on its shoes over the sand surface, water is forced thru hollow shaft "*A*" to the hollow rim of the wheel "*B*" and thence to the hollow teeth "*C*" thru fine perforations into the sand; the dirty water from the washt sand being drawn away from the washing chamber thru suction pipe "*D*."

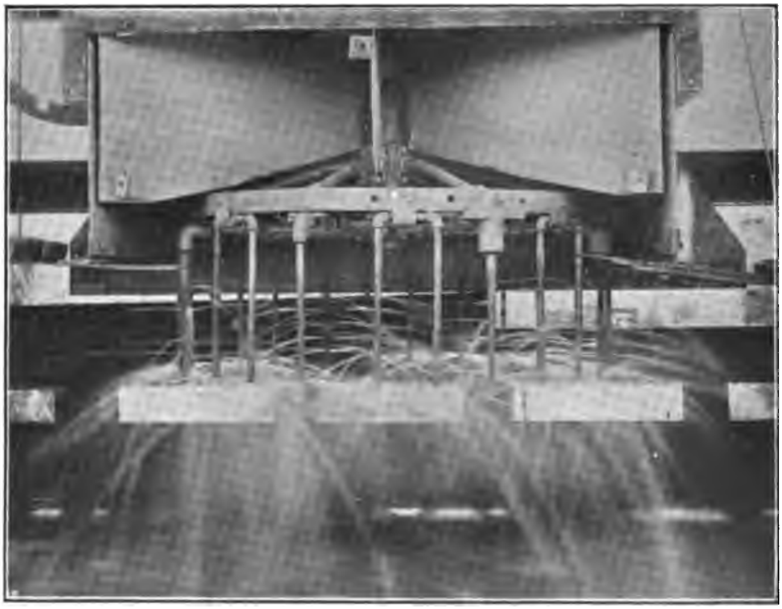

FIG. 2.—WASHING BOX OF FILTER WASHING MACHINE WITH ONE SIDE REMOVED, SHOWING REVOLVING WHEEL AND TEETH, AND WASH WATER SPRAYING THRU TEETH.

at the high rates has always been as satisfactory as at low rates. The following table gives a direct comparison of two such runs each at high and low rates.

TABLE COMPARING RESULTS OF HIGH AND LOW RATES OF FILTRATION AT JEROME PARK RESERVOIR EXPERIMENTAL FILTER STATION.

Number of Run.	High Rate.		Low Rate.	
	8A	8B	9A	9B
Av'ge rate of filtration, mil. gals. daily per acre.	9.66	9.66	3.00	3.00
Duration of run, days	3.86	3.86	7.91	7.91
Loss of head during run, ft	4.21	5.08	5.30	5.04
Yield, mil. gals. per acre	34.6	40.0	23.9	23.9
Average bacteria, raw water	260	260	170	170
" " subsided water	270	270	180	180
" " effluent	28	26	24	14
Average Turbidity.—Raw water	4	4	4	4
Subsided water	4	4	3.7	3.7
Effluent	0.5	0.5	0	0
Micro-organisms.—Raw water	......	......	648	648
Subsided water	858	858	695	695
Effluent	0	0	0	0
Amorphous matter.—Raw water	......	......	275	275
Subsided water	80	80	225	225
Effluent	0	0	0	0

REMOVAL OF ALGAE, MICRO-ORGANISMS AND AMORPHOUS MATTER.

All of these were present in the Croton water at all times, and often in quite large amounts. They were easily removed, their only effect being to shorten the runs between cleanings, which, in view of the quick method of cleaning described later, did not present any serious problems.

REMOVAL OF COLOR.

The color due to vegetable stain has been removed to an average extent of about 25 per cent. This would leave a noticeable color in the effluent for some eight months of an average year, and experiments have been made looking toward other methods of removal during such time.

Treatment by ozone was lookt upon most favorably, but on trial it proved unreliable in action and of prohibitiv cost, and it was necessary to turn to coagulation and sedimentation. It was found impracticable to remove the color by means of lime and sulfate of iron unless applied in quantities prohibitivly expensiv. Sulfate of alumina, in quantities averaging about one grain per gallon, effected the necessary result when followed by a period of sedimentation equal to about seventeen hours' flow.

CLEANING THE FILTER SAND—BROOKLYN METHOD.

During the first forty-five runs the experimental filters were cleaned by the Brooklyn system, which consists essentially of shutting off the bed to be cleaned, and draining off the water to within about one inch of the top of the sand. A current of raw water at the velocity of about one-half foot per second and about an inch deep is then run over the sand surface and into a sewer outlet, while men stand in the running water and with common garden rakes stir up the top layer of sand, thus washing out the dirt, which passes away with the water. After the sand is cleaned to the depth the rake teeth penetrate, the filter is refilled with raw water, and again started on its regular run.

It was found that this method of cleaning was very satisfactory tho the length of the runs were somewhat short. After one or two washings, the tops of the beds became very hard, similar to a sand beach, and there was but a very slight penetration of the schmutzdecke, scarcely a quarter of an inch. The hardness of this top surface was undoutedly a prominent factor in the good bacterial records of the runs. The hard surfaces had smaller voids, kept the filtration uniform over the entire filter, and prevented breaks in the schmutzdecke, so that within one or two hours after starting the run there were only very few bacteria in the effluent.

The writer is of the opinion that another factor in the excellent bacterial purification is that no refilling of the filter backward thru the underdrain is necessary. With the water always flowing thru the filter in one direction, there is no disturbance of conditions. The sand bed is not softened and "springs" or breaks are not formed at each run, nor the nitrifying organisms disturbed below the immediate top layer.

The amount of water used at a cleaning was about 200 000 gal. per acre, and can be taken from above the sand from an adjoining filter by openings thru the walls controlled by sluice gates, requiring no pumping and the use of only raw water.

The Brooklyn system as described above can be readily adopted on a large scale for Croton water, and is not only cheaper but more

PLATE 4.
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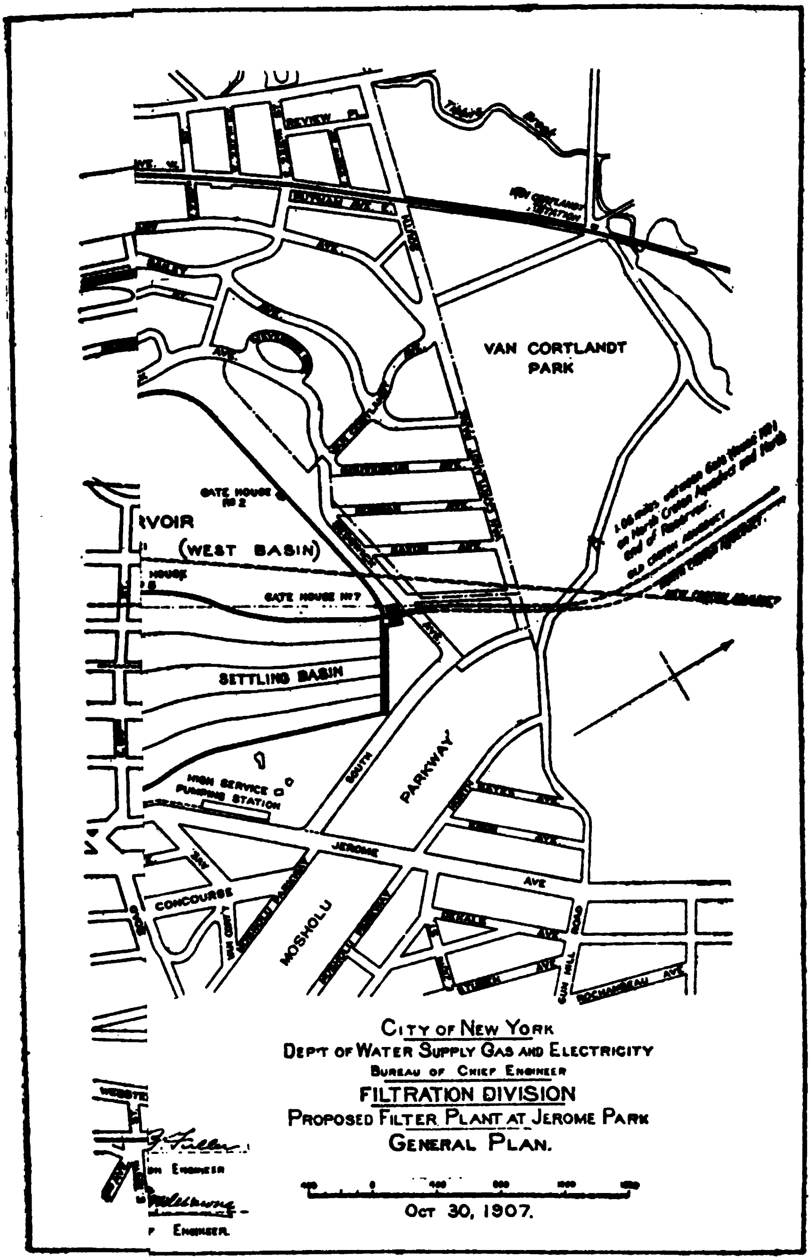

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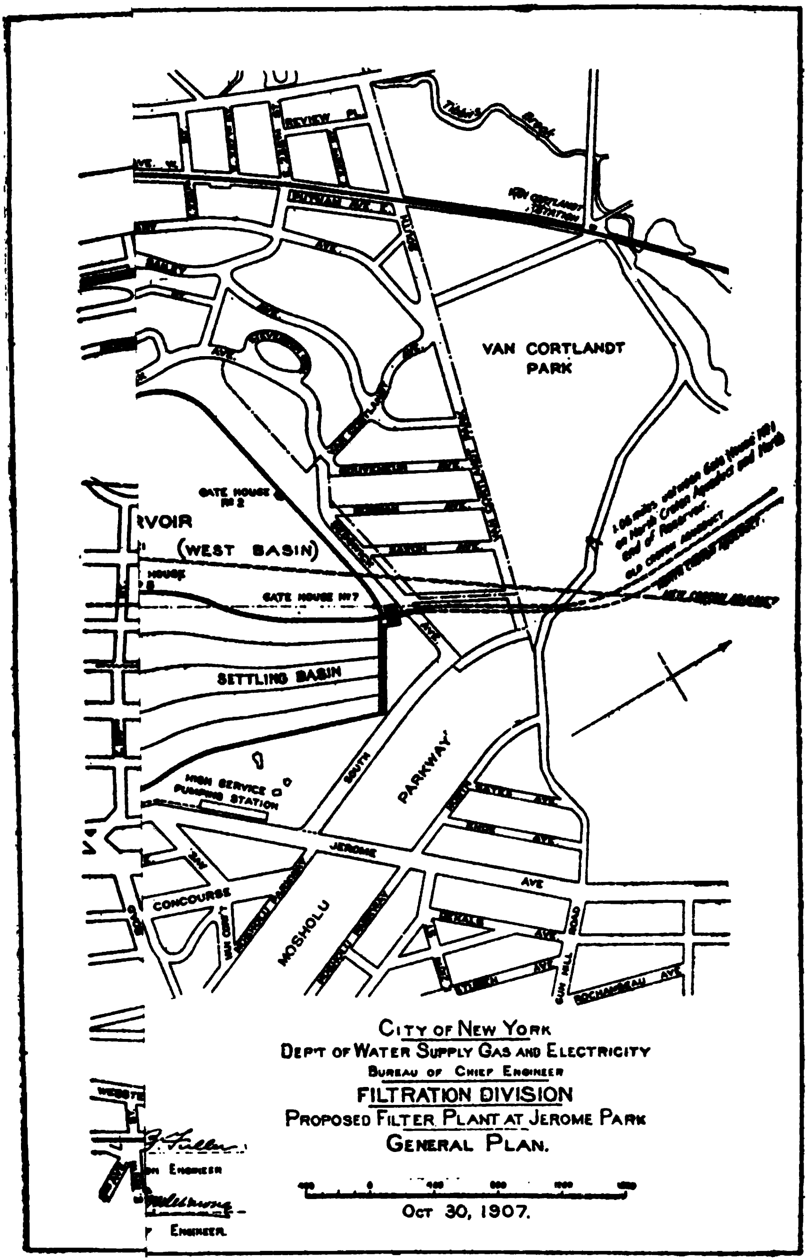

rapid than the present systems of removing the sand from the beds, washing and restoring. For high rates of filtration, however, there is still too much time lost in draining and refilling the bed, requiring a considerable reserve area to keep up the nominal output.

Cleaning the Filter Sand—Blaisdell Method.

During the past six months the experimental filter beds have been cleaned by a Blaisdell filter-sand washing machine, a patented device under the control of the Blaisdell Filtration Co. of Los Angeles, Cal. Such a machine has been in operation at Yuma, Arizona, for four or more years, on a sand filter, clarifying Colorado River water, having an average turbidity of 1 200, at a rate of 3 million gal. per acre per day, thru sand having an effectiv size of 0.13 mm., without the use of any coagulants, at a very small maintenance cost, and with satisfactory results. This machine was invented and installed at Yuma after a prominent mechanical filter company had installed a plant which failed to improve the water and was abandoned.

At Yuma no attempt was made to ascertain the bacterial efficiency of the filtrate, the only desire being to get clear water, and the Blaisdell Company, recognizing the need of a demonstration machine more accessible than at Yuma, and under competent supervision, offered to bild and operate the one at the Experimental Station at Jerome Park Reservoir at their own cost, and as a result a very strong and substantial machine, thoroly practical in all its details, and much improved over the first Yuma machine, has been designed, constructed and operated by Mr. George P. Baldwin, Chief Engineer and Eastern representativ of the Company.

The Blaisdell Washing Machine.

The Blaisdell washing machine consists of an inverted open box about 4 ft. square and 2 ft. deep. This box is sunk under the water of the filter to the sand surface, and is held in position and operated from a platform above, which platform is movable on rails supported by the piers of the filter. The box contains a revolving hollow axle and a hollow head, from which hollow teeth project into the sand any desired distance. (See Plate 3, Fig. 1.)

By means of suitable electrically driven mechanism, all under the control of one operator, the box can be raised or lowered, and the platform can be moved forward, backward or sideways. By moving the platform, the box is caused to slide over the surface of the sand at a speed of about 10 ft. per minute, while at the same time the hollow head and teeth are made to revolve slowly, stirring the sand mechanically. Water under a pressure of 10 to 20 lb. per square inch is introduced thru the hollow axle, head and teeth, and passes in strong fine streams into the sand thru fine holes in the teeth. (See Plate 3, Fig. 2.)

A suction pump, connected with the top of the box, is made to draw away just a little more water than is supplied thru the teeth and thus carries away and discharges to a sewer all the dirt which has been stirred and washt from the sand.

On account of some water being drawn inward from the filter into the box under its edges thru the sand to make up the deficiency between the amount pumpt out and that let in thru the teeth, none of the dirty water escapes from the box into the filter, but is all carried away and discharged thru a flexible hose into the sewer. The box is slowly moved ahead over the sand and thus every part of the sand surface is gone over and cleaned (see Plate 2, Fig. 2), after which the machine is lifted from the filter and filtration started. All of the operations of the machine are at all times easily under the control of one operator by simply throwing electrical switches.

It has been found that this method of cleaning has been the most satisfactory yet tried. There is no time lost in removing the water from the bed and refilling, the only time the filter is out of service being during the process of cleaning, and this time can be reduced to a very small amount by concentrating several machines on one filter. With filters constructed to the design which will be described later, each bed will be out of service only 40 minutes and the reserve area required is reduced to less than 2 per cent.

Cleaning of the sand is not limited to a thin top layer as in present methods, but can be carried to any depth desired, the usual procedure being to use 2-in. teeth for ten or twelve washings, and on the next washing to use 8-in. teeth. This insures a thoro washing of the sand and eliminates any question of sub-surface clogging.

A noticeable factor in the use of this machine is the entire

PLATE 5.
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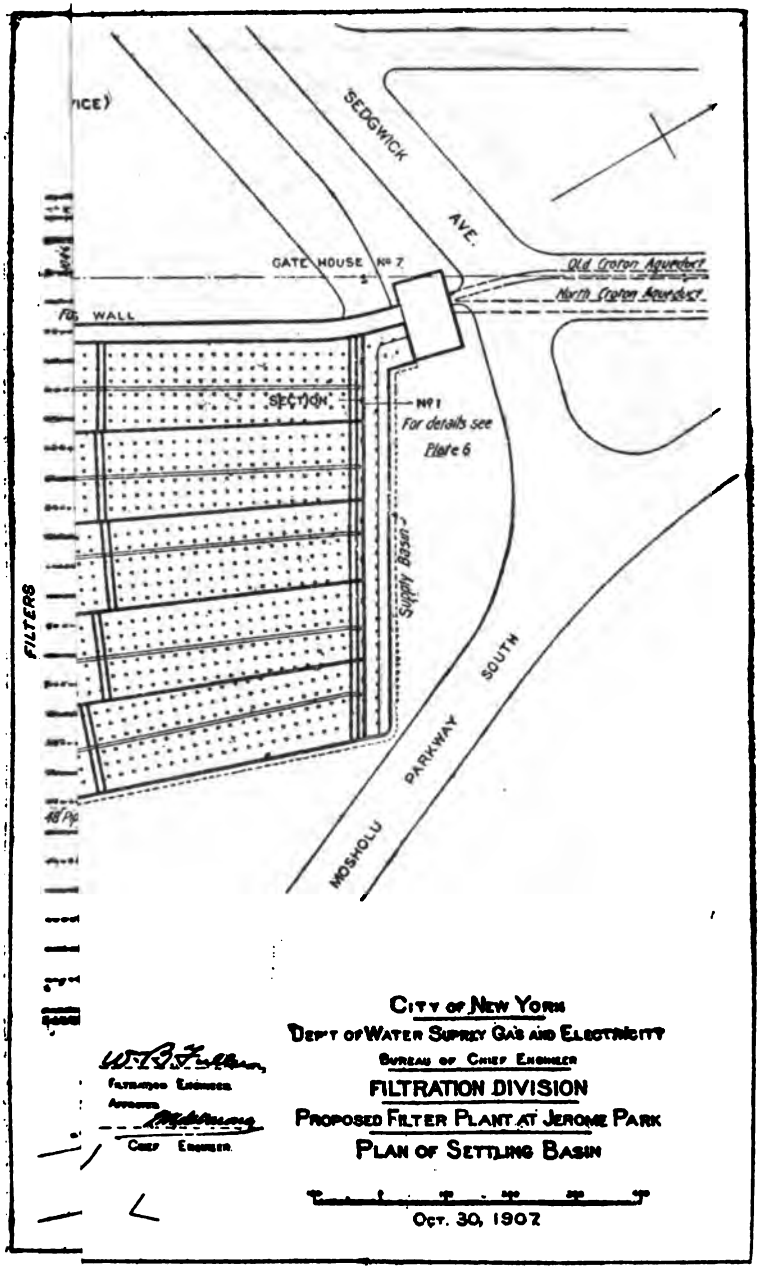
FULLER ON PROPOSED FILTRATION
OF CROTON WATER SUPPLY.



W. B. Fuller
Filtration Engineer
Approved
Chief Engineer

City of New York
Dep't of Water Supply Gas and Electricity
Bureau of Chief Engineer
FILTRATION DIVISION
Proposed Filter Plant at Jerome Park
Plan of Settling Basin

Oct. 30, 1907

removal of entrained air from around the sand particles, insuring probably a most even rate of filtration over the bed. The hardening of the bed as described under the Brooklyn system is also noticeable here, but the upper two inches remains softer than the sand below and the yield of each run is much greater than with the other system.

The bacterial results have always been very satisfactory after two hours from the time of starting the run. By introducing a small amount of the discharge from the dirty sand directly in the rear of the machine, where it will be drawn into the clean sand by the excess draft towards the washing chamber, it is quite probable that the bacterial results may be made satisfactory immediately after starting, but this has not yet been workt out in practis.

The machine uses about four horse-power of electrical energy, about 80 000 gal. of wash water per acre, is operated by one man, and, as now designed, will clean about one-eighth of an acre per hour.

FIRST DESIGN OF FILTER.

On the organization of the work in May, 1906, it was desired to begin work on construction at the earliest possible moment, and, while the Consulting Engineers, as well as the author, were quite sure that Croton water could be filtered at the rate of ten million gallons per acre per day, and were also sure that some rapid method of cleaning the filters would be evolved, it was deemed best to await the results of the Experimental Station work before a definit decision was made. Accordingly designs were drawn for a rate of 5 million gallons daily, and allowance made for cleansing the sand by the usual process. This design was somewhat similar, with the exception of the two-storied feature, to the design of the Pittsburg filters, which, in their turn, were made similar to the design by the author of the Stormville filters for filtering the proposed additional water supply for New York City, as recommended by the Burr-Hering-Freeman Commission in 1903. Its distinguishing features were dry galleries between the filters for the operations of sand washing, and the usual pipes and condits required for such a plant.

In October, 1906, plans and specifications for one-half of the area of these filters were sent to the Board of Estimate and Apportionment with a request for the necessary money to construct this number, which would be required at any rate of filtration and leave the question of rate to be decided later.

PRESENT DESIGN OF FILTERS.

The Board of Estimate and Apportionment failing to make the necessary appropriations in the fall of 1906, the entire question of design was again gone over with the information gained from the experimental work, and new designs workt up, based on using the Blaisdell method of cleaning, and the 10 million gal. per acre daily rate exclusivly, and it is these designs which are now presented.

GRADES OF FILTER AND LOSS OF HEAD.

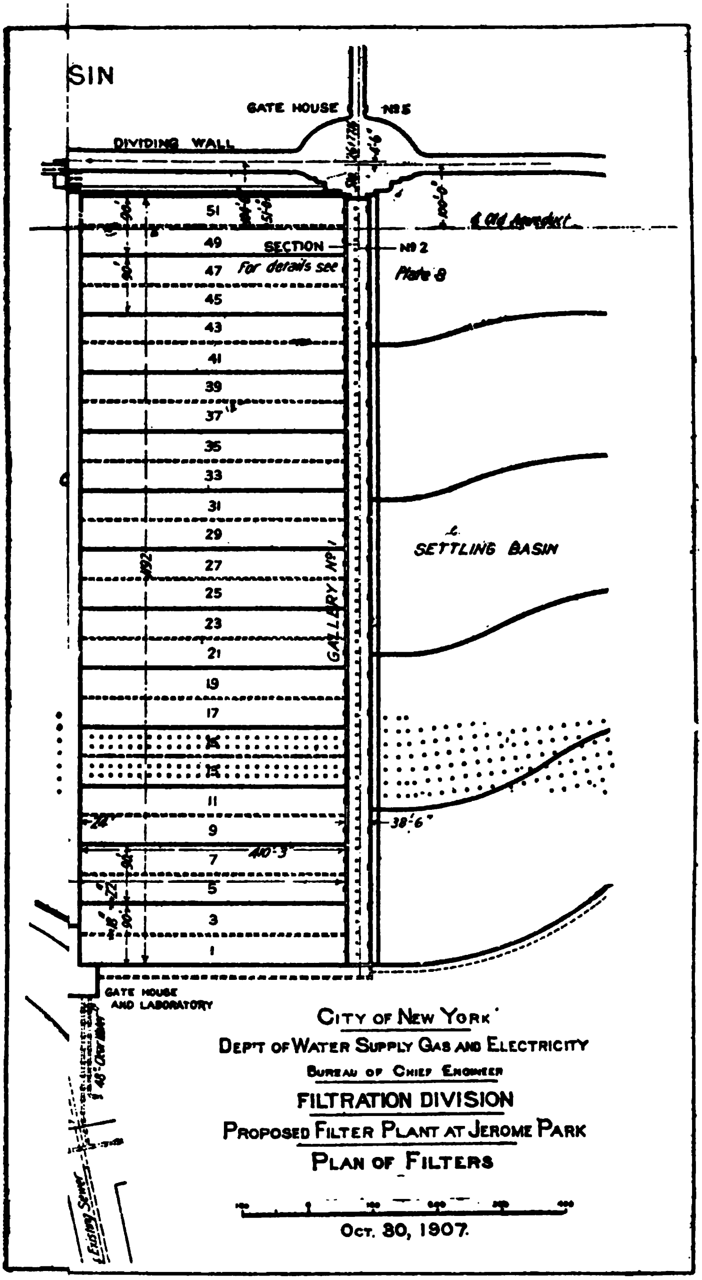
The hydraulic grade line of the New Croton Aqueduct entering Jerome Park Reservoir is 131.5, while that of the Old Croton Aqueduct is 128.0. Experiments were made on the carrying capacity of the New Croton Aqueduct between Jerome Park Reservoir and Central Park showing it to be 230 million gal. daily at grade 128. This, added to the capacity of the Old Croton, gave 320 million gal. delivered from Jerome Park Reservoir at grade 128 to Central Park Reservoir when full, an amount entirely sufficient. The elevation of high water in the clear well was therefore fixt at 128.0.

As the hydraulic grade line of the New Aqueduct is nine inches below the inside crown, it was considered entirely feasible to raise the hydraulic grade line at this point to 133.0 putting the aqueduct under a pressure of 9 in. This gives 5 ft. gross head for the operations of the filter, an amount entirely sufficient. It will be necessary to raise the water from the Old Croton Aqueduct 5 ft. to the level of the filters, but all the water flowing thru the New Croton Aqueduct will reach the filters by gravity. By placing the New Croton Aqueduct under a little more head, all the water required can be brought to the filters thru this aqueduct, and the Old Croton Aqueduct be held in reserve, as it has been for many years. This is entirely feasible as the aqueduct is almost entirely in tunnel and, with a full lake, 45 ft. of head is lost at the inlet from Croton Lake.

DESCRIPTION OF THE PLANT.

Water from the two aqueducts comes together in Gate House No. 7 at the north end of the reservoir, as shown. (See plate 4.) Here

PLATE 7.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FULLER ON PROPOSED FILTRATION
OF CROTON WATER SUPPLY.



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that of the Old Croton Aqueduct is raised 5 ft. by centrifugal pumps driven by electric motors. The two combined waters then flow into the uncovered West Basin where the water level will be raised 1½ ft. higher than at present. After traversing the length of this basin it will be brought back to Gate House No. 7 thru large condits already constructed in the division wall. Here, if necessary, sulfate of alumina will be added to remove the color, and the water will enter the settling basin at the north end of the East Basin, from whence it will slowly flow to above the sand in the 42 acres of covered filters, thence thru the sand to the clear water reservoir below, or to the covered one to the south, and thence to the city supply.

SETTLING BASIN.

The settling basin shown in plan on Plate 5 and in detail on Plate 6, is to be a covered basin with an area of 37.3 acres. It is divided longitudinally into five compartments, any one of which can be emptied and cleaned without interfering with the others, or with the operation of the plant. The roof of the basin is of concrete groined arch construction, of 18 ft. clear span, supported by colums 2 ft. in diameter, and 23 to 25 ft. high. The groins are covered with 2 ft. of soil. At four places along the length of the basins are arranged wiers, which cause the water to mix by passing first to the surface and then to the bottom. At the end of the basins the water is taken off into the filters over a wier near the surface. The velocity of travel of water in the basin, when working at its full capacity of 400 million gal. daily, is 24 in. per minute at the north end and 12 in. per minute at the south end, and the period of sedimentation is 18 hours.

FILTERS.

The filters are bilt of concrete, and, as shown in plan on Plate 7, consist of 104 covered beds, each having a net area of 0.4 acres, giving a total area of 41.6 acres. They are situated directly over and supported by the north portion of the clear well. The covering consists of concrete groined arches and 2 ft. of soil.

The filters are made long and narrow and are arranged in four rows of twenty-six filters in each row, each two rows being separated by a gallery. Between the filters and the settling basin is a raw-water gallery, serving as a by-pass in case any of the settling basins or north tier of filters are out of service. The raw water enters this gallery from the settling basins (see Plate 6) and passes directly to above the sand into the north tier of filters, thru 26 sluice gates from which it spreads out over the entire 104 beds like a great lake. There are no condits leading the raw water separately to each bed, but the water for the south tier of beds flows slowly over the intervening beds.

Plate 6 also shows a cross-section of the raw-water gallery and the entrance of the water to the first tier of filters. Plate 8 shows the second tier of filters, the dividing wall between the second and third tier, the transfer gallery between the third and fourth tier of filters, and the detail between the fourth tier of filters and the clear-water reservoir. It will be noticed that the water is 5 ft. deep over the sand. It is intended to operate the filters with 4 ft. loss of head, and the extra foot is an insurance against negativ head under the sand layer. The sand layer is only 26 in. deep, this being considered quite sufficient considering it is not taken from the filter for washing, but always remains in place. The gravel is in five graded layers, having a total thickness, including the underdrains, of 16 in. The underdrains are made of hard burned terra-cotta ducts, as ordinarily used in the streets for electrical condits. There is no main collector except across one end of each filter. The controllers shown in cross-section on Plate 8 and in longitudinal section and plan on Plate 9 are placed in a dry tunnel situated under the transfer galleries of the filters, and as can be seen there are but short connections of pipe to them from the main collectors and thence to the clear well. These short pipes are the only piping in the plant.

The controllers will be of the enclosed pressure type, so the clear well can be held at any desired elevation and the filters still operate regularly.

The transfer galleries are for the transferring of the washing machine from one filter to another. It will be noticed that each filter opens its full width on the transfer galleries so there will be no delay in moving the machines from the gallery to the filter or *vice versa*. It is not expected that the water above the sand in any filter will have to be drawn down very frequently, but when it is

PLATE 8.
THE MUNICIPAL ENGINEERS
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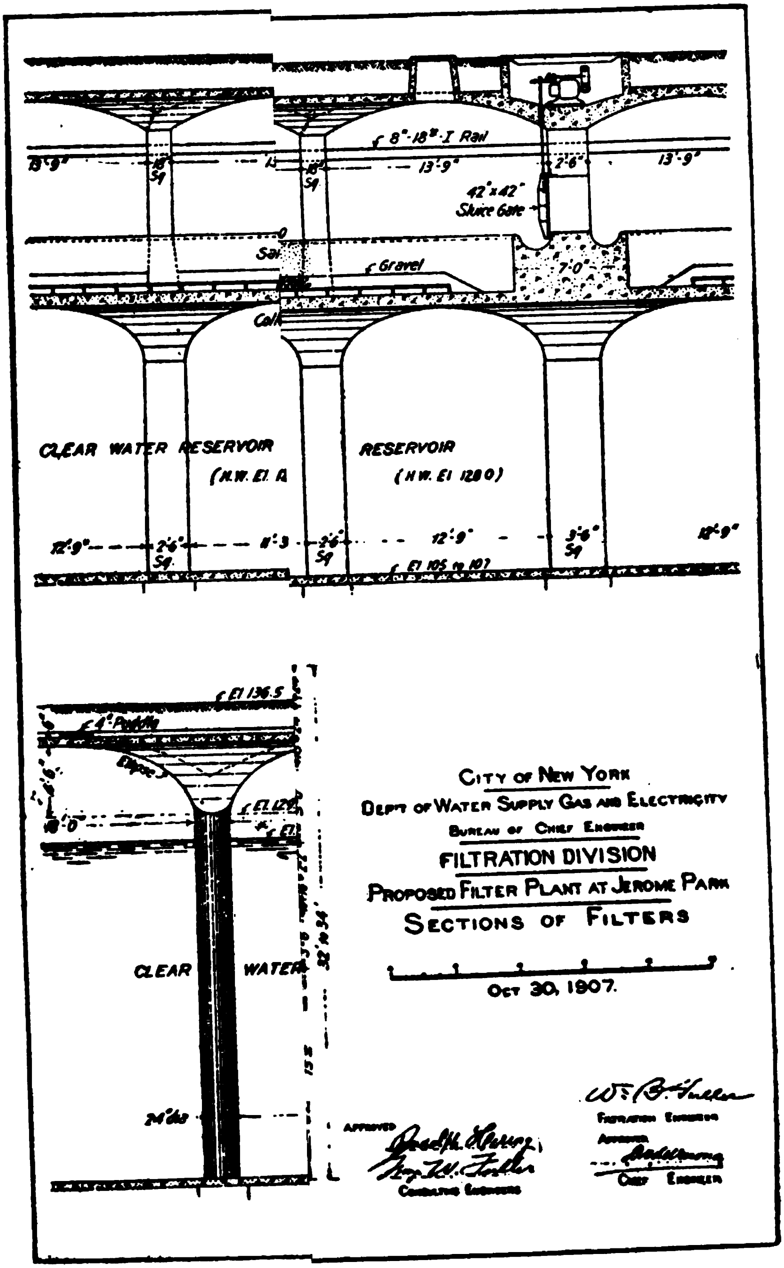
FULLER ON PROPOSED FILTRATION
OF CROTON WATER SUPPLY.



City of New York
Dep't of Water Supply Gas and Electricity
Bureau of Chief Engineer
FILTRATION DIVISION
Proposed Filter Plant at Jerome Park
Sections of Filters

Oct 30, 1907.

Wm. B. Fuller
Filtration Engineer

Approved
Rudolph Hering
Geo. W. Fuller
Consulting Engineers

Approved
Chief Engineer

desired to do so, large sliding sluice gates in the gallery can be made to close off any pair of filters, and the water drained off thru the small sluice gates near the gallery.

The Blaisdell washing machine is shown in position of cleaning on Plates 8 and 9, all the mechanism being contained in a boat floating in the water, and guided by rails supported by the piers of the structure.

It is to be noticed that where raw and filtered water are separated only by masonry, a dry gallery or chamber is interposed, so as to guard against leaks from the raw to the clear water, the dry chamber taking any leakage and conveying it to the sewer.

Clear Water Reservoir.

The clear water reservoirs under the filters and to the south end of the reservoir, occupy an area of 94.8 acres and have a capacity of 567 million gal. They are constructed of concrete, being covered with groined arches and earth, similar to the rest of the plant.

Service Bildings.

There will be four large service bildings bilt of granit in a plain but imposing style.

The first, known as Gate House No. 7, to the north of the plant, will contain the gates for turning the water from the aqueducts into the West Basin and settling basin, the electrically driven centrifugal pumps, and the coagulating devices for the removal of color. The second, Gate House No. 5, is the service gate house, regulating the distribution of filtered water to the Old and New aqueducts, and to the various pipe lines leading from the reservoir. The third, situated at the head of gallery No. 2, will be used as a laboratory and office for the management of the works. From one table in this office, all the valves in the filters will be under electrical control and all the washing machine operators will be in communication by telefone, so any individual filter can be shut off by one operator in the office, after notice by the machine operators that they are ready for cleaning, and started again the instant he is notified that the cleaning is finisht, thus assuring a filter out of service the shortest possible time.

The fourth bilding is the machine shop; in outward appearance, exactly like the laboratory bilding, but devoted to a shop for the repair of the washing machines, and contains rooms for the filter attendants, gardeners, etc.; also an electrical lighting plant for the entire works, including power enough for the operation of the washing machines.

Plate 1 is a sketch showing a perspectiv view of how the surface of the top of the filters may be treated as a park and recreation ground. The plans and elevations of the bilding and the perspectiv view were made by Henry Ives Cobb, architect, with offices at 52 Broadway.

COST OF CONSTRUCTION.

It is estimated that the work as above described can be completed in three working seasons and at a cost not exceding $8 500 000, of which $3 500 000 is primarily for filters, and the balance of $5 000 000 would have been incurred under any plan for finishing and covering the East Basin.

COST OF MAINTENANCE.

It is estimated that the entire plant will be operated an entire year at a cost of $125 000 for labor, $140 000 for coagulant, and $35 000 for depreciation and repairs; a total of $300 000 per annum, or $2 per million gal. filtered.

In closing the author would say that he believes this filter plant necessary; first, for protection from the constant yearly increase in typhoid; second, to remove the color and mud and give to the citizens at all times a bright and clear water fit to bathe in; third, as a protection against a short supply should a dry year occur before the Catskill water is available. That is, it will allow of all the reservoirs in the Croton watershed to be drawn down to a much greater extent than would be possible without filtration. Fourth, that New York may have equally as good water as that supplied to any city in the world.

DISCUSSION.

Mr. George W. Fuller.—Mr. President and Gentlemen: The interesting paper of Mr. Fuller describes a project which is unique in many ways. Perhaps the chief characteristic is the unusual effort which has been made to adjust this design to the work to be accomplisht, when due regard is paid both to efficiency and to economy. This feature crops out in many ways. Perhaps the most notable feature of the project is its relativ size in proportion to the work to be done, and calling, of course, for a rate of filtration in consequence which is higher than has been ordinarily used. This rate is not entirely without precedent, however, as it has been based upon a large number of experimental studies involving thousands of analyses, part of them made at the Lawrence Experimental Station and part of them made here in New York, as Mr. Fuller has told you, at the Jerome Park Testing Station. Other tests have been made elsewhere, particularly with the muddy waters of the Mississippi basin, after those waters have been freed from the bulk of the clay. This rate is very little more that what has been regularly used with the comparativly clear water of Lake Zurich. It should be stated that this is a maximum rate, using some 40 acres of filters regularly in service for the filtration of the nominal carrying capacity of the two aqueducts, which is about 400 million gal. daily.

I want to point out to you very plainly that there is a wide difference ordinarily between the nominal or average rate of filtration and the maximum rate. The so-called 2½ or 3 million gallons per acre daily rate frequently means a 3½ or 4, or even 4½ million gal. rate. In this Croton project we are dealing with a very large supply and the monthly fluctuation in consumption is very small indeed; as I remember, the maximum is only about 6% above the mean of the entire year. It is not intended to operate the proposed Croton filters above a 10 million rate.

With reference to the work which has to be done, the proposed Croton filter will have to take out mud, objectionable vegetable stain or color, objectionable micro-organisms giving tastes and odors which are unpleasant, and it will also have to deal with the removal of bacteria of a disease-producing character and which are gradually increasing in numbers. For a great many years the Croton water supply has rankt as one of the good supplies of this country, in fact, among the good supplies of the world; but the increasing population on the watershed is making it more and more of a problem to keep down the death rate from water-born diseases among its users. That is particularly true as the consumption is increasing and making the storage capacities of the reservoirs in point of time relativly less, notwithstanding that analyses show that this water from the

Croton compares favorably with many filtered waters and the death rates are on the average well in accord with that finding. The trouble with the Croton water, from a hygienic standpoint, comes after the heavy rains, and particularly when the reservoirs are low. I am assured by Commissioner Darlington of the Health Department, that there is no dout in his mind that after such rainfalls occur that there is clearly an effect produced on the death rate as a result of this water.

Comparing this water with that of the muddy rivers which are sewage laden, there is not a very great deal of work to be done in its filtration, and that is one of the reasons why this rate of filtration is not only permissible, but is safe, and one which I thoroly believe in as practicable. The most feasible rate is one associated somewhat, under the local conditions, with the character of the water, as regards its ability to be filtered by the ordinary sand method. It differs essentially from the clay-bearing waters, which do not contain the organic matter which is necessary to form gelatinous or sticky films around the sand grains. This Croton water, like the Lawrence water from the Merrimac River, does contain such films; and the process of filtration to a considerable degree is a physical one, allowing the bacteria to be caught or detained on these gelatinous surfaces of the sand grains and held there until they die for want of food, or because of other unfavorable conditions.

It seems to me that the best way in which I can illustrate this question of rate is to say that if a dam is to be bilt to withstand a water pressure of say 100 ft. at the bottom of the reservoir, it might have a width of 60 or 70 ft.; now, if you want to bild a 50-ft. dam you would not make the base, at the bottom of the reservoir, to stand a 50-ft. pressure, 60 or 70 ft. wide, but it would have a width of perhaps 30 or 35 ft. I want to emphasize again that this point is one which has been adjusted very carefully in a study of the conditions under which the work of this filter will have to be done.

This filter, also, on account of its having to remove a considerable quantity of vegetable stain, will be assisted by coagulant at times, and that coagulant, applied at the inlet of the settling basin which has been shown you, will cause particles of the vegetable matter to adhere to hydrate and form flocs which will deposit. Some of those particles, however, will pass over on to the sand layer and will assist in forming these films of a gelatinous nature and serve as a considerable safeguard in securing the desired hygienic results.

Another feature of this filter plant is the method of cleaning. I believe that the majority of you who are familiar with filtration matters will recognize at once that this is an adaptation to the sand filtration process of the hydraulic method of cleaning which has been in use for many years for mechanical filters. I consider that this is perfectly practicable. It has been demonstrated, as Mr. Fuller has told you, at Jerome Park and by practical experiences at Yuma, Arizona. It is based, I believe, on correct principles and is a stepping stone to markt advances in the economy of sand filtration practis. Its merit depends considerably, I believe, upon the use of a sand layer where the sand grains are sufficiently uniform in size so that there will not be a markt stratification, or an irregular deposit of sand grains, according to their sizes. This application of water thru the perforated teeth, of course, moves them about materially, and it is quite natural that the larger particles will settle back into their places more quickly than the smaller ones. By making the particles substantially uniform and copying the results of experiences in mechanical filtration for the past twelve or fifteen years, I believe that this marks an important step.

In regard to the cost of filtration for the Croton project, it is comparativly small for the amount of work to be done and the conditions dealt with. The use of this proposed rate of filtration, perhaps double what has been used in some places elsewhere, does not mean that the cost of the filter project is cut in two, because the condits and many of the devices remain more or less the same, but it does allow a substantial saving that is worth striving for, I am sure, in these days when cities have so many different projects to provide and the filtration engineer and the waterworks engineer have no monopoly on the various demands for municipal improvements.

In regard to the question of cost of operating the filters, that item is independent of the rate; that is to say, the load which this filter carries, if it filters 60 million gallons per acre between cleanings or 100 million gallons, whatever that figure may be it is substantially independent of the rate, so that the rate of filtration affects the investment cost only, and the operating expenses will here be reduced as a result of the improvement in cleaning methods and not as a consequence materially of size of plant or rate of filtration.

It is rather unique to see a filter plant of the sand filtration type bilt above a filtered water reservoir. That, of course, has been done in a number of instances with mechanical filter plants, as at Little Falls, N. J., and elsewhere.

I think there is no room for dout about this being the most advantageous site under the existing conditions here locally. It enables use to be made of land already owned by the City and allows the filtered water to be stored beneath the filters at an elevation which will not affect the pressure in the City as the water passes from the filtered water reservoir.

The question of laboratory devices and facilities for controlling these works is one that I believe is worth pointing out in particular, as showing a general feature which has already been in use in connection with the management of the waterworks affairs of this City for many years; and that is the control, thru frequent analyses, of the water supply from its various sources. That work represents many thousands of analyses each year, and I believe that with this plant bilt and with the system of control which has been in effect for many years in this department of the City, the water consumers will get a good water, one which will be free from turbidity, color, objectionable tastes and odors, and one which will have a markt effect in lowering the already low death rates from water-born diseases.

Mr. Bernard M. Wagner.—I have been very much interested in the paper by Mr. Fuller, but there are some points that appear to me to be slightly doutful. One is the use of the mechanical cleaning device. A device of this nature is liable to all kinds of mishandling in the hands of an average city employee. This and possible damage from moisture are features about which I think there might be a question. Then again, Mr. Fuller spoke of discharging some of the mud back of the cleaning device, and it seems questionable whether, in the agitated condition of the sand, more mud than desired would not be drawn into the beds and really wipe out the effects of the cleaning. I would be glad to have some information concerning actual results of this process. I would also like to know what provision is made for cleaning the underdrain, whether any device is provided for regulating the elevation of the water surface on the filter beds, and some information concerning the pumpage. The total cost of $2 per million gal. for operation is so low, as compared with results obtained elsewhere, that specific data on the subject would be very acceptable.

Mr. Robert Ridgway.—We will have the questions answered later. Can we hear now from Mr. George A. Johnson?

Mr. George A. Johnson.—Mr. President and Gentlemen: It seems to me that Mr. Fuller has given us a very clear conception of the plans which it is proposed to put into effect whereby the citizens of New York will be provided with a water supply which will be almost absolutely pure, and satisfactory not only from a hygienic standpoint, but also from the most exquisit esthetic standpoint, thru the removal of suspended matter and color.

Perhaps the most markt change from ordinary water filtration practis which has been recommended and which it is proposed to put into actual effect in this project, is this somewhat higher rate of filtration than has been used elsewhere up to this time.

A rate of filtration of about 3 million gallons per acre daily is one which we have been accustomed to look upon as more or less of a filtration law, altho it has been well understood for many years, such understanding being derived from elaborate experiments on the part of the Massachusetts State Board of Health and others, that rates of filtration materially higher that 3 million gallons are often perfectly feasible. In fact, our conclusions, as arrived at to-day, indicate that the rate of filtration is very largely to be governed by the rapidity and facility with which the filter beds may be cleaned. These devices which Mr. Fuller has described to us this evening, and the results accomplisht with them, indicate that the difficulties surrounding this phase of the matter have been satisfactorily overcome and that it may be possible to put into actual practis rates of filtration which have not been shown in the past to be feasible.

A noteworthy example of high rates of filtration on slow sand filters that perhaps may not have come to the attention of the members here this evening, is in Yokohama, Japan. At Yokohama their first slow sand filter was bilt over twenty years ago. The raw water is derived from a river which rises near the foot of the famous Mt. Fuji, and flows thru agricultural districts, which are bountifully fertilized with human excrement, and the necessity for a thoro treatment of this water before consumption is well understood. Since the inauguration of these works, the filters have been operated at a rate of 6 million gal. and upwards per acre daily.

The raw water receives no preparatory treatment before filtration, but flows thru a gravity condit from its source to the filter plant, is there delivered into a small receiving tank, from which it flows directly onto the slow sand filters, where it is treated at the comparativly high rate I have stated. These filters are constructed according to ideas as they existed twenty years ago, altho the more recent filters are bilt along more modern lines. The filters are composed of medium sized sand which is obtained from the beach of Mississippi Bay. There were no analyses of this sand available, but I judge it to be a sand which would have an effectiv size in the neighborhood of .25 mm. The bacterial results from these filters are exceptionally good and the water is drank—particularly by the natives, and more sparingly by the foreigners—without particular suspicion, which is an unusual thing in Far Eastern countries. The water contains some color and at times, following heavy rain-storms, a great deal of turbidity, but on the average these filters, even tho operated at this rate, yield a water which apparently is satisfactory in all ways, and the filters require scraping only about once in every thirty days.

MR. ROBERT RIDGWAY.—Will Mr. Chase say something on this subject?

MR. RICHARD D. CHASE.—I have listened with a very great deal of interest to the paper to-night and I wish I felt competent to discuss it at the present time, but there are too many novelties outlined to speak on them without careful preparation. I think the gentlemen concerned deserve a great deal of credit for designing a plant containing so many unusual features, which, if bilt, will mark a very distinct advance in the operation of slow sand filters.

MR. EDWARD WEGMANN.—I suppose it is well understood that the original idea of constructing the Jerome Park Reservoir was to provide at least ten days' storage in the City of New York in case of an emergency. In Central Park there are only 1 200 million gal. storage, and the designer of the Jerome Park Reservoir, the late Mr. Fteley, was very anxious to secure at least ten days' storage within the limits of the City. In looking at these drawings, the first impression would be that a considerable amount of the storage had been lost by the sand beds, supporting arches, piers, etc., I would like to ask Mr. Fuller how much storage will be sacrificed in the Jerome Park Reservoir by introducing the filter beds in the East Basin?

MR. ROBERT RIDGWAY.—Perhaps Mr. Flinn would be willing to give us some information on this subject.

MR. ALFRED D. FLINN.—A year and a half ago, it was my pleasure to be in Yuma. Altho I did not have time to visit the filtration plant, I did see a good deal of Colorado River water and some of it looked almost solid with the sediment it carried. It has a very heavy burden of silt, but the water that was served from the filters, on the other hand, was satisfactorily clear, and I understand that these filters, using a very fine sand, as filter sands go, have been satisfactorily removing the sediment and turbidity from that water. Mr. Fuller or Mr. Johnson can correct me if I am wrong, but I think the Yuma sand compares with the fine sand of the Holland dunes and has an effectiv size of perhaps 0.2 mm. I brought home some samples and made analyses. I understood from Mr. Blaisdell, whom I saw a short time later in Los Angeles, that the interesting device employed at Yuma for washing filter sand was a development from mining machinery, in the manufacture of which he was engaged when he became interested in the water company at Yuma, and was led to it as a matter of necessity. A detail in the development of the shape of the filters may have past notice. Instead of the nearly square beds we have been accustomed to in the ordinary slow sand filter, the use of such machinery makes desirable a long and narrow bed, so that the machines will make a long cut,

MR. HERMAN A. RUGE.—Filtration is a slow progress, and *the slower the better.* More than 3½ million gallons per acre should not be filtered in twenty-four hours, and the filter-bed of sand and gravel with the finest sand on top, should not be less than 6 ft. thick. The method of cleaning the sand has been explained by the author, especially the top layer, which becomes clogged with algæ, dirt and microbes. It is a new method and may work apparently very nicely on a small scale in the laboratory, but on a big scale the scouring and rotary raking up of the surface is dangerous, as the bacilli of an infectious disease will not all leave the filter-bed. They will be scoured around and altho many will be flooded out, yet many may settle down on the disturbed sand bed and penetrate more easily into and thru it than when it was covered with the film of the algæ. This is the danger of the system described by the author.

In the paper the city of Zurich in Switzerland has been mentioned. I was connected with the filter beds in Zurich at the time when they were constructed. Before they were constructed a sudden epidemic occurred, which caused considerable criticism. The water had been taken from the lake, which was perfectly clear, and pipes were laid up the river to the mouth of the lake from which the water was drawn. While making an excavation for the foundation of a new bridge an old abandoned sewer was encountered. The workmen cleared away the débris as well as they could, but the excavated material went into the lake and polluted the water. The consequence was that in a fortnight the death rate from typhoid rose to 6% of the population of the city. Then it was resolved to bild a filter system. When cleaning these beds, the top surface of the sand, about ½ in. in depth, was carefully skimmed off and washt by working it up an inclined plane with a series of rakes working together, while the water was running down from above, thus cleaning the sand. The amount of water required to clean one cubic yard of sand was a little over half a cubic yard. This was easily accomplisht by use of this patent sandwasher, which is in use at several filter-beds in prominent cities in Europe.

Mr. Robert Ridgway.—Will Mr. Fuller please answer the questions now?

Mr. William B. Fuller.—Answering Mr. Wagner's questions in regard to a few of the details:

The cleaning device as proposed would be run by electricity and would require no more care or skilled labor than the running of an electric elevator, one man at $3 per day of eight hours performing the entire operations required. The machine is very simple and strongly bilt, and could hardly get out of order even if badly mishandled.

The replacing of a small portion of the removed mud or schmutzdecke behind the washer, so as to bring about immediate stable conditions of filtration without wasting the first portion of the filtrate or slowing down the rate of filtration is, as has been said in the paper, still in an experimental stage, and not yet workt out in a practical way. It is believed that it will be practically solved, but after all, this would be only a minor improvement, because the experiments already conducted indicate that two hours is about the limit for running the filtrate to waste before reaching a good standard of purification, while with ordinary sand filters the period is now from one to five days.

In such a large plant as the one under discussion, with one bed being cleaned at a time out of the 104 beds in operation, the proportionate increase of bacteria due to the first 2 hours of the run would be very small and could be neglected, as is now usually done in mechanical filtration.

In relation to the controller, there has been no thought as to the exact design, with the exception that it should be a closed controller. Every new design of a filter plant brings forth a new crop of designs for controllers, engineering practis in this particular not having as yet been standardized.

In regard to maintaining the level of water on top of the filters, the endeavor of the paper has been to make it plain that the water surface of all the filters is at one elevation like a large pond, and there are no condits, regulators or other apparatus to convey raw water to any individual filter. The absence of these previously considered necessary appliances constitutes one of the essential improvements in the design.

If it is desired to examin the sand in any one filter, that filter is shut off by large floating gates, the water remaining at the pond elevation all around. The elevation of the pond of water is determined by the amount of water let into the gate house at the upper end of the reservoir. The gates in this house will be motor operated and in charge of an attendant, who will keep the water at the desired elevation.

In relation to Mr. Wegmann's statement of 10 days' storage at Jerome Park Reservoir, while this may have been the amount stated at the time of its design, the storage is only 1 700 million gal., or about 4½ days' supply at the rate provided for filtration.

In answer to Mr. Ruge, the design and operation of successful filter plants in America does not bear out his unqualified statements as to rates of filtration or thickness of sand layers, and it is the writer's experience that higher rates and thinner beds of sand than he has mentioned will give the best purification.

In relation to the cleaning of the sediment from the basins: The basin is divided into five parts, so that any one of those parts can be cleaned without interfering with the others. The cleaning is done by opening a blow-off valve and running the water away to a sewer; or if that becomes objectionable, as it may, there is provided an area where that water can be run into a reservoir, where it would settle, the top being then drawn off into the sewer and the settled material from the basin carted away.

In regard to the cost per million gallons, it must be remembered that this is a gravity plant; there is no cost of pumping or anything of that kind, and the labor cost is reduced very materially because there will be only a small number of laborers employed on the work. It is designed to have twelve machines, which will take thirty-six operators, and then, of course, there will be other men around, but a very small number compared with a corresponding area of any other type of filter.

Mr. B. M. Wagner.—Do you not pump water at the gate house?

Mr. Fuller.—There may be a small amount of pumping in connection with raising the water from the old Croton level to the new Croton level. That is, it may be 90 million gallons raised 5 ft. It is a very small amount compared with the total output, and so small that it would probably be done with electrical motors, using the electricity from the plant.

It should have been mentioned that in the machine shop there will be an electrical plant which will produce electricity enough for lighting the entire plant, running the washing machines, and this small amount of pumping. It is quite probable that after the new additional water supply arrives, Croton Lake will be kept at its highest elevation at all times, and, in that case, all the water needed for the plant can be brought thru the New Croton Aqueduct, and there will be no need of using the Old Croton, except in an emergency.

Mr. Wagner.—Have you had any trouble in the under-drains?

Mr. Fuller.—No, we have had no trouble of any kind.

Mr. Wagner.—Is there any way of getting at the under-drains?

Mr. Fuller.—This is not specially provided for. They are laid in straight lines and could, of course, all be examined by digging up the upper and the lower end.

In relation to reduction of storage in Jerome Park Reservoir, I would say that practically there is no change. It is the intention to raise the hydraulic grade of the New Croton Aqueduct 1½ ft. as it enters Jerome Park Reservoir. That adds 1½ ft. to the depth of water in the west reservoir, and this amount about compensates for the amount taken off from the east reservoir by the filters.

Mr. Arthur S. Tuttle.—I would like to ask the author:

1st. Whether the west basin will continue to have any value for storage purposes if the filtration plan is carried out?

2d. Whether the filter beds are separated so that each could be operated at an independent rate, as might be at any time desired?

3d. Whether the capacity of the new condit would be appreciably reduced by the proposed slight lowering of the hydraulic gradient at the reservoir, and whether the old condit is strong enough to be used under sufficient pressure to avoid the necessity of pumping?

Mr. Fuller.—In regard to the use of the west basin, it is considered merely as an emergency basin. There is some 600 million gal. of water in the clear well, which is about a day and a half's supply. In view of the fact that up to last October New York City has been adequately supplied without any storage in Jerome Park Reservoir, it would seem as if, perhaps, a day and a half's supply might be quite sufficient for some time to come, but if any emergency occurred in which it was necessary to use still more—that is, to use the west basin after the storage of the east basin was entirely depleted; it would be right at such a time to use the settled water in that basin without filtration. It should be remembered also that the Board of Water Supply propose bilding a large distributing reservoir at Hill View, about three miles farther north, and at a much higher elevation. When this is done the need of a large reservoir at Jerome Park will have disappeared.

The question of one filter operated at a different rate from another is taken care of by the mechanical controllers on each filter. Each filter is controlled by a mechanical device which makes that filter, independent of all other filters, operate at any rate desired. It is not necessary or probable that all the filters will be operated at the same rate at any one time.

Mr. Tuttle.—I understand that the sand beds must be separated.

Mr. Fuller.—They are separated by walls. There are 104 beds in all, each entirely separate and each one can be operated independent of the other.

The old condit is still in very bad condition and it would be very inadvisable to put any pressure on it whatever, but, as I stated, it is hardly necessary to use it, because any needed pressure can be put on the new condit by simply reinforcing it in two or three places. This pressure can be increast up to a head of 45 ft., in which case 550 million gallons would pass thru the new condit line, and there would be no use for the old condit, except in a case of emergency—that is, in case there was something wrong with the other.

Mr. Tuttle.—That would be by pumping, of course.

Mr. Fuller.—No, by gravity alone. There is 45 ft. head lost at the intake at Croton Lake, when Croton Lake is full, and that 45 ft. could be utilized after the Catskill water arrived, as with plenty of water the lake could be kept full. That 45 ft. could be always utilized in bringing the water to the City—that is, you can bring 550 million gallons to the City thru the present New Croton Aqueduct. This will probably be taken advantage of by the Board of Water Supply, because they can finish all of their aqueduct above Croton Lake, discharge into Croton Lake, and finish the lower part of the aqueduct while the water is being delivered to the City.

Mr. Ridgway.—That would require the reinforcement of the aqueduct, would it not?

Mr. Fuller.—That would require the reinforcement of the New Croton Aqueduct in three or four places only, at a very small cost.

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SUBSURFACE INVESTIGATIONS OF THE BOARD OF WATER SUPPLY FOR THE PROPOSED CATSKILL AND LONG ISLAND AQUEDUCTS AND RESERVOIRS.

BY MESSRS. DWIGHT S. MALLETT, ROBERT RIDGWAY, WILSON FITCH SMITH AND WALTER E. SPEAR.

RESERVOIR DEPARTMENT.

BY MR. DWIGHT S. MALLETT,* MEMBER OF THE SOCIETY.

The careful study of subsurface conditions prior to the construction on the Esopus Creek of the main dams for the Ashokan Reservoir, the chief storage reservoir in the Catskill Mountain Water Supply Project, was necessary because of the possible selection of a dam site at which foundations, insecure for a high dam, might have been accepted as satisfactory, this error resulting in the future in the failure of the dam. The two chief consequences of such a failure would be as follows: First: New York City would meet with the loss of one of its best and largest water supplies, which loss, should it occur in a period of drought, might leave the City open to pestilence, destructiv fires, and a disastrous loss of business. Second: At the instant of failure of the dam, a torrent of water would rush down and devastate the fertil lowlands of the Esopus and destroy parts of the city of Kingston, for which devastation, New York City would rightfully be held responsible. Accordingly it became necessary to select as a dam site a place where there could be no dout as to the soundness of the subsurface conditions.

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* **Member of Engineering Corps, Reservoir Department, Board of Water Supply.**

Before going into the study proper of subsurface conditions it seems best to describe, in general, the means by which it was possible to obtain the necessary data. The study of the geology of the Esopus valley, from the U. S. Geological Survey data and from field explorations, gave a general idea of the relations which might be expected to exist between the surface and bed-rock. This study, while of some help as a guide, was by no means all that was necessary in the selection of the best dam site. Surface indications, unless they consisted of bed-rock outcrops, were of little value in determining the depth of earth overlying bed-rock. The consideration of locations and comparison of water levels in springs and wells gave but little information in regard to strata existing in the earth. The only means of obtaining reliable and sufficient information in regard to subsurface conditions was the employment of drills in making borings.

There being more drilling than the Board of Water Supply drills could possibly accomplish in the short time in which it was necessary the work should be completed, some 6 000 lin. ft. were completed by Sprague & Henwood, by contract. The drilling outfits used by the Board of Water Supply and by Sprague & Henwood differed only in the make of drill, the former using a Badger, and the latter a Sullivan drill. Each outfit consisted essentially of boiler, Badger or Sullivan hydraulic drill respectivly, diamond bit, steam pump, derrick, wash-pipe, casing, necessary tools and fittings. and was valued at about $2 000.

The difficulty in drilling lies in sinking the casing thru the earth to the bed-rock, the rock drilling being a comparativly simple matter. In general, earth drilling is accomplisht as follows:

1st. After the drilling outfit is set up, a hole is dug with pick and shovel, some 2 or 3 ft. in depth.

2d. A length of 3-in. casing, with the lower end protected by a drive-shoe and the upper end protected by a drive-head, is inserted in the hole and driven by the alternate raising and dropping of a heavy weight, either a block of iron or wood, as far as the casing will easily penetrate the earth, say 2 or 3 ft. The raising and dropping of the heavy weight is made possible by the use of a long rope past over a pulley at the top of the derrick, one end being fastened to the iron weight, and the other wound two or more times around the drum of the drill.

3d. A wash-pipe, having at the lower end a perforated chisel chopping bit is lowered within the casing to the bottom, 5 and 10 ft. lengths being coupled together to form a total length sufficient to project above the top of the casing.

4th. The steam pump having been connected by means of a rubber hose and water swivel to the top of the wash-pipe, water in the desired quantities is forced thru the wash-pipe and perforated chisel chopping bit into the earth at the bottom of the casing. The result is that the water loosens the earth, and, flowing between the wash-pipe and the casing to the surface, carries the loosened earth with it, thus creating a hole at the bottom of the casing. As an aid to the action of the water, the wash-pipe, by the use of the above mentioned rope, is alternately raised and dropt, thus chopping up the earth.

5th. The casing, by means of the heavy weight, is driven into the hole which has been created.

The above process of alternately washing and driving is continued, 5 and 10 ft. lengths of casing and wash-pipe being added as they become necessary, until the casing is firmly seated on the bed-rock.

Two of the more common difficulties to be encountered in earth drilling are as follows:

1st. The encountering of boulders. When the casing strikes a boulder the driller will lower dynamite down the casing until it rests on the boulder and will then, after the casing has been pulled up several feet so that it may not be injured, explode the dynamite. It may be necessary to repeat this operation several times, before the boulder is crusht, and often it is found necessary, after one or more days of fruitless labor, to abandon this means of attack altogether. The only thing left to do is to drill a hole thru the boulder, with the diamond bit, after which it is an easy matter to lower dynamite into the boulder and completely crush it. Very often, in trying to drive the casing past a boulder, the casing is bent or broken. In the first case, the casing must be pulled from the ground and replaced by straight casing. In the second case it is probable that the casing cannot economically be removed from the earth, in which case, it will be economy to abandon the boring and set up at a new location a few feet distant.

2d. The encountering of sand. Strata of sand 10 ft. or more in thickness will sometimes make trouble, for the sand may run up in the casing or set very compactly about it, it being, in either case, very difficult to make satisfactory progress. When the bed-rock is covered by 150 ft. or more of compact earth, it is best to use several sizes of casing, the larger size being first sunk as far as possible and then telescoped by the next smaller size, which is in turn driven as far as it will readily go. This process is continued until the bed-rock is reacht.

After the casing is well seated on the bed-rock, so as to prevent earth from hindering the drilling, rock drilling is carried on as follows:

1st. The wash-pipe, having, in place of a chopping bit, a core-barrel 10 ft. long, to which is fastened a core-shell with a diamond bit, is lowered within the casing to the rock. The diamond bit may be described as approximately an inch length of soft steel pipe of diameter according to size, one end being threaded so that it may be fastened to the core-shell, the other end containing eight black diamonds, four set in the inside and four in the outside of the cutting edge. All the diamonds project slightly from the metal, the four in the outside of the cutting edge so as to cut a hole in the rock large enough to receive the core-barrel, and the four in the inside so as to cut a core small enough to pass thru the bit and core-shell into the core-barrel.

2d. The upper end of the wash-pipe is then attacht to the drill, and the steam pump, as in the earth drilling, is connected with the wash-pipe by means of a rubber hose and water-swivel. The drill causes the wash-pipe with the diamond bit to revolve and at the same time exerts a downward pressure in addition to the weight of the wash-pipe, which tends to force the diamond bit into the rock. The steam pump forces water thru the wash-pipe, core-barrel, core-shell, diamond bit, thru grooves in the cutting edge of the diamond bit and then up between the rock and wash-pipe into

PLATE 10.
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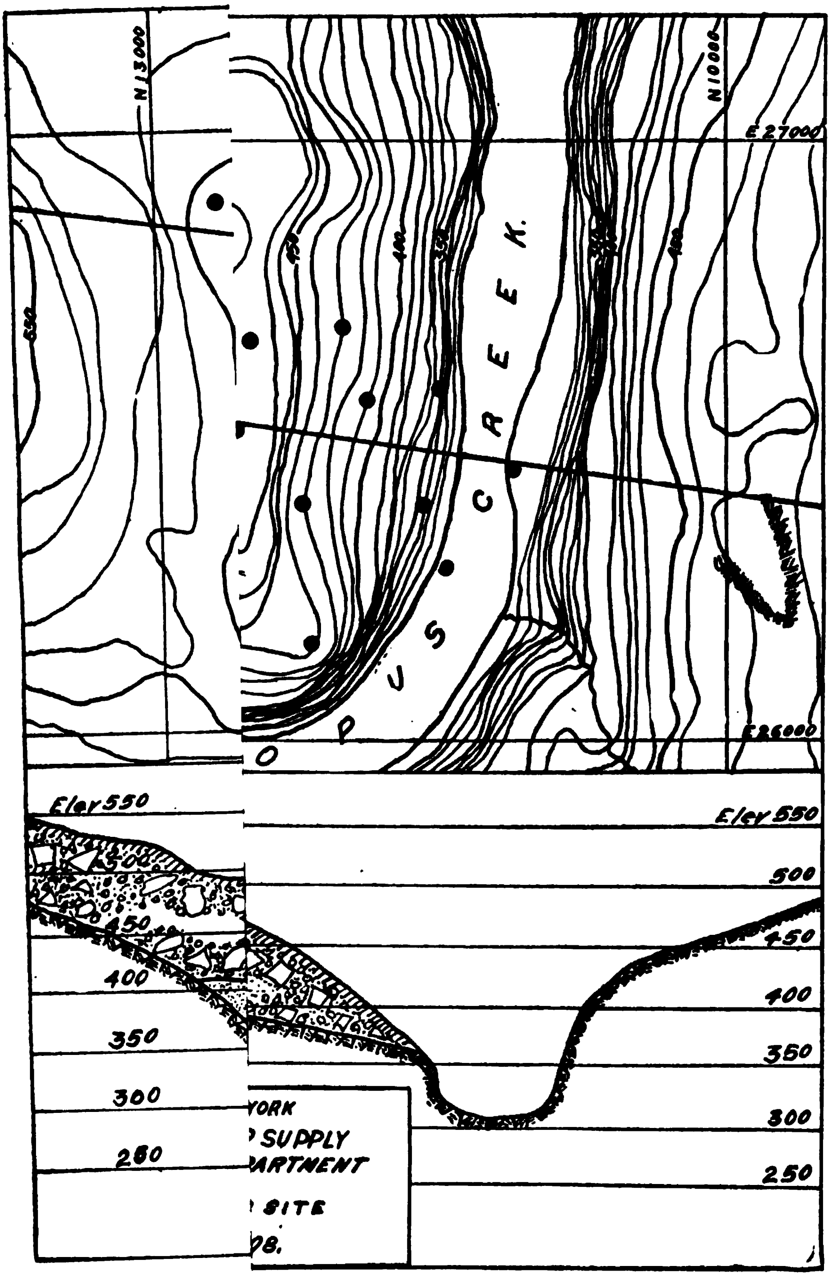
MALLETT ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Plantion, and Filled with Water-Bearing Sand.

the casing, and thence to the surface, the water, in its progress preventing the diamond bit from becoming too hot and freeing it from the rock cuttings which are carried away to the surface.

3d. When the core-barrel becomes full of core, or if the core becomes wedged in the core-barrel, further core will be prevented from passing into the core-barrel, thus making it necessary to pull up the wash-pipe, core-barrel and diamond bit, in order to remove the core which is prevented from slipping out of the core-barrel by a core-lifter situated in the core-shell. The above process will be continued as described until the desired depth in rock has been drilled.

Some of the difficulties and dangers in drilling rock are as follows:

1st. If the wash-pipe is handled carelessly, while being lowered in the casing, or while being pulled up, the wash-pipe, with the diamond bit, may slip and fall to the bottom of the boring. This would probably mean great injury to and perhaps the loss of a diamond bit, worth say $800.

2d. If the water fails for a short time to pass thru the wash-pipe and diamond bit, it may cause the diamond bit to become stuck; this will injure, and perhaps cause the loss of the bit.

3d. Seamy rock, or rocks containing a large percentage of quartz, are injurious to diamond bits, the former thru the breaking or chipping of, and the latter thru the wear on the diamonds.

The methods used in earth drilling by the Board of Water Supply drillers and by Sprague & Henwood's drillers differed slightly. The Board of Water Supply drillers did not drive the casing severely, but chose rather to flood the casing in order to loosen the material about it, while the Sprague & Henwood drillers never flooded the casing and always drove it severely. Flooding is accomplisht by forcing water down the casing, the water passing out of the casing, following up along it and eventually coming to the surface about the casing. In rock drilling, Sprague & Henwood's drillers having drills with hydraulic feed attachment held the advantage over the Board of Water Supply drillers having the Badger drill with screw feed attachment, for the former were able to vary the feed according to the nature of the rock, while the latter could only use a constant feed no matter what was the nature of the rock.

Drilling, from a contractor's point of view, is a risky proposition, for he may meet with a substantial gain or a heavy loss. Sprague & Henwood have done drilling by contract at the rates of $3.50 and $4 per lin. ft. The conveying of water, either by wagons or by pumping station and pipe line to the various drilling outfits is often an item of great importance to the contractor.

The sinking of shafts is the most reliable means in the investigation of subsurface conditions. Shafts make it possible to see and determin the exact subsurface conditions. Unfortunately, on account of the heavy expense involved, it is not possible to use shafts very extensivly. Borings, however, supplemented by shafts for the sake of comparison, give satisfactory results. In all, five shafts were excavated on the two dam sites for the Ashokan Reservoir by contract let to Naughton Co. The dimensions of the shafts were 16 by 24 ft. In the sinking of a shaft the earth was excavated by pick and shovel and removed from the shaft by derrick and buckets. After the earth had been excavated to a depth of 12 ft., 3-in. sheeting 12 ft. long, supported at each side and end respectivly by three 12 in. by 12 in. rangers and three 12-in. by 12-in. braces, were used to hold back the earth. After the first 12 ft. of excavation sheeting in 6 ft. lengths were used supported at each side and end by two 12-in. by 12-in. rangers and two 12-in. by 12-in. braces respectivly. When strata of soft running sand were penetrated, poling boards were used until harder and more impervious material was reacht, at which point poling boards were given up, and sheeting used. For the total depth of the shaft the rangers and braces were supported vertically by posts. Water caused much trouble in the sinking of the shafts, even making it necessary to abandon one shaft altogether. Boring cost the Board of Water Supply about $3.50 to $4 per lin. ft., the shafts 0 to 20 ft., $55; 20 to 50 ft., $70; 50 to 100 ft., $95; 100 to bed-rock, $105 per linear foot.

The two important points to be kept in mind in the study of subsurface conditions at a site for a high dam are, first, soft, porous strata of earth, as sand or sand and small stones, and second, water-bearing seams in the bed-rock. In the sinking of a shaft, it is easily determined whether the earth is soft or compact by its appearance, by the amount of labor required in its excavation and

PLATE 11.
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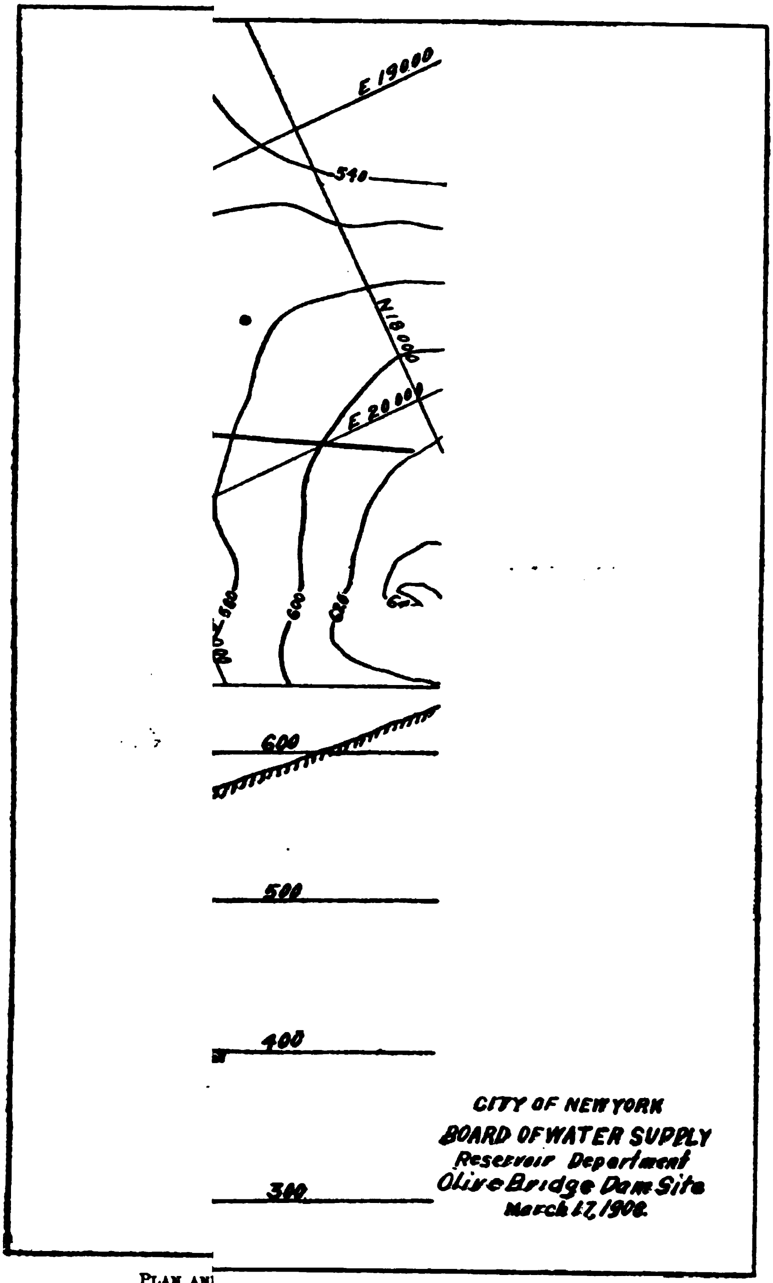
MALLETT ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



PLAN AN
TION AND FILLED WITH IMPERVIOUS MATERIAL.

by the rate of progress. In soft, porous earth, it is probable that the earth upon coming in contact with water will run into the shaft. Moreover porous strata will attract attention generally by the appearance of the earth and especially by the presence of large quantities of water. Unless the excavation of the shafts be continued on into the rock, nothing can be ascertained by the shafts concerning the soundness of the rock. In the cases of all five shafts sunk at the dam sites for the Ashokan Reservoir, one or more borings made near the site of each shaft, at a time previous to the sinking of the shaft, had indicated approximately the same conditions as were actually found to exist; thus the reliability of data furnisht by borings was establisht. In general, subsurface conditions were more satisfactory as the borings were more difficult to make. In drilling, there is said to be a loss of water, when all or part of the water forced thru the wash-pipe does not return to the surface, but instead, runs or soaks away in the earth. If slow progress, say 8 ft. per day, is made with difficulty, no water being lost in the earth, and a mixture of clay, sand and small stones being carried from the casing by the wash water, strata compact and not water-bearing are indicated. If the above drilling were accompanied by a loss of water, strata composed of porous material as small stones or small stones and sand would be indicated. If, however, in drilling, rapid progress, say 20 ft. per day, is attended by no loss of water, the water bringing clay and sand to the surface, a material not compact but impervious to water is indicated. If the above drilling were accompanied by a loss of water, water-bearing strata with little or no clay would be indicated. In rock drilling a loss of water shows the presence of an open water-bearing seam, but if the pieces of core when removed from the core-barrel are discolored at the ends, no water having been lost while drilling, seams not necessarily water-bearing are indicated. The action of the drill when working will indicate the nature of the rock whether soft or hard and the presence of seams, the drill running evenly and smoothly in sound homogeneous rock but unevenly and in a jerky manner in disintegrated and non-homogeneous rock. The core, upon inspection, will definitly show the nature and variety of rock encountered.

Whenever the character of the earth or bed-rock seems to be doutful, and if the size and importance of the structure to be bilt warrants investigation in addition to the drilling, if the casing has been left in place in the earth, water under pressure may be used to obtain further information. In testing the rock, the casing should be firmly seated in the bed-rock and water should be forced thru it into the rock at the desired pressure by means of a pump and pressure-gage. Small and large losses of water indicate small and large seams respectivly. If the casing is not so firmly seated in the bed-rock as to prevent the water from passing between it and the rock, water-levels in the casings, taken by means of tape and sounder, will indicate the elevation of the water-table. The presence, or absence, of water-bearing strata of earth is indicated respectivly by a similarity or dissimilarity of elevations of water-levels in the casings of several adjacent borings.

The geological formation of that part of the Catskills about the Ashokan Reservoir, which formation is known as the Hamilton beds, is simple compared with the complex formations, thru which the Catskill Aqueduct must pass on its way from the Ashokan Reservoir to New York City. The Hamilton beds are composed of extensiv strata of shale and sandstone, the latter of which has been extensivly quarried in the past. The Catskill mountains are the water-worn remains of a high plateau elevated above the sea-level by the great mountain-making movement known as the Appalachian. In some geological periods previous to the Glacial, the Catskills stood at a much higher elevation than at present. This difference in elevation, while due in part to erosion, is chiefly the result of a sinking of the land as a whole. The old stream beds having been deeply eroded in the rock, approaching sea-level in elevation, as they neared their mouths, now appear as deep channels in the rock in places far below sea-level partly or wholly filled with glacial drift and sediment. As an example we have the Hudson River with its old, partly filled preglacial bed many feet below sea-level, and likewise the Esopus Creek, a tributary of the Hudson, with its old preglacial bed, in places near its mouth, many feet below the surface of the Hudson, and consequently below sea-level, now filled with glacial drift. The preglacial bed of the Esopus Creek from its mouth to a point upstream from the Ashokan Dam sites is filled with glacial drift, so that at present

PLATE 12.
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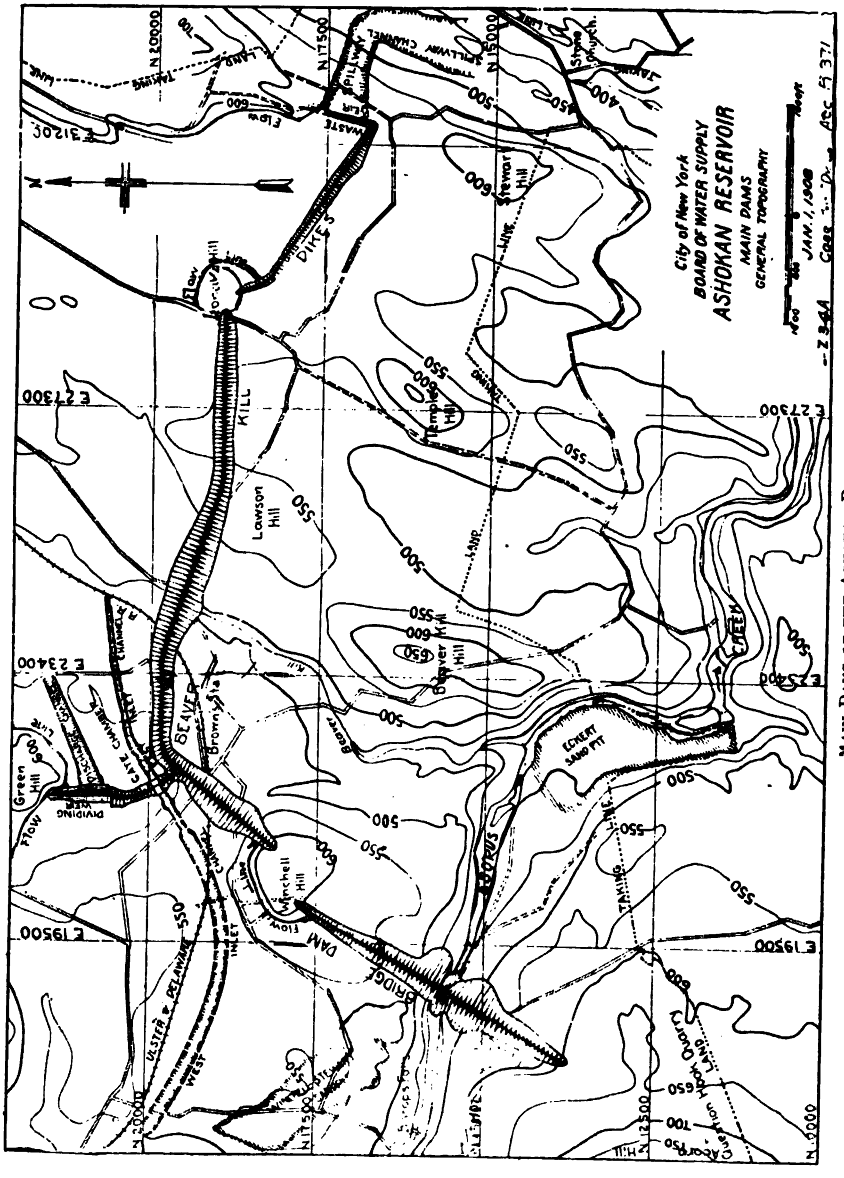
MALLETT ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Main Dams of the Ashokan Reservoir.

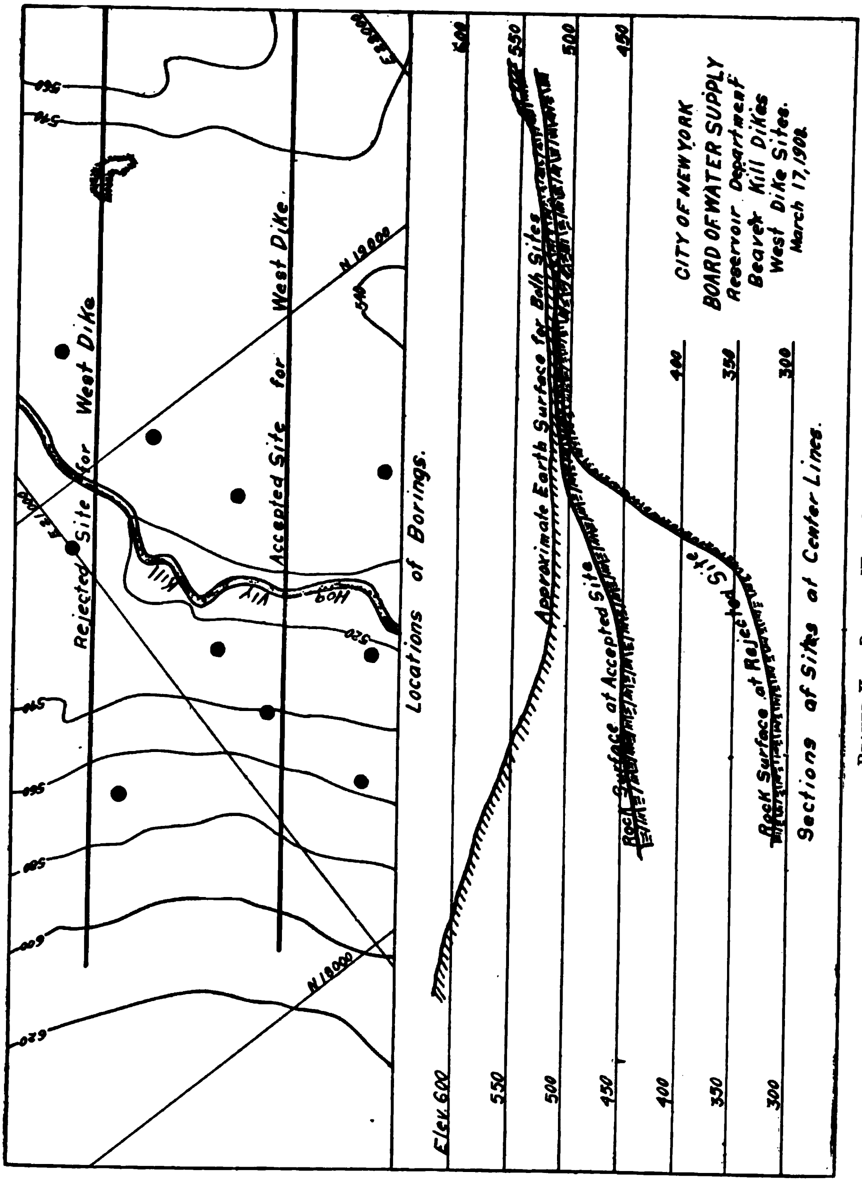
the creek, while it seems to follow approximately its former course, lies at the dam sites at an elevation of perhaps 100 ft. above its preglacial bed. The glaciers in their movement from northeast to southwest seem to have pusht the Esopus out of its old channel and up its south and west banks, where it has eroded its present bed, forming gorges in the solid rock in places 100 ft. deep. Near the principal dam sites, as located by means of borings and bed-rock outcrops, the preglacial bed of the Esopus lies in general several hundred feet to the north and east of its present channel.

On the Esopus Creek there were two possible dam sites for the Ashokan Reservoir, one at Tongore and the other at Olive Bridge. Surface topography favored the Tongore dam site with a location for dams aggregating 2 miles in length, the maximum hight of the dam being 290 ft., as compared with the Olive Bridge dam site where dams aggregating 3.8 miles in length, of maximum hight of 210 ft. would be necessary. The choice of the Olive Bridge dam site was determined chiefly by subsurface conditions.

At the Tongore dam site a long high dam and two short low dikes were necessary. The sites for the dikes were satisfactory, one dike being only a few feet in hight and the other being founded on bed-rock which was covered by only a thin layer of earth. The difficulty lay in determining a satisfactory location for the high dam. The subsurface investigation of the Tongore dam site required three test shafts of an aggregate depth of 200 ft., costing $12 600, and 74 borings of an aggregate depth of 8 300 ft., costing $29 000. The center line of the dam site ran from a steep hill on the south bank of the Esopus to the north, across the Esopus and thence up along the crest of a long drumlin terminating near its summit.

The part of the dam south of the Creek could easily have been founded on bed-rock, which was practically without earth cover. Borings in the bed of the Esopus, which here runs in a rock gorge 100 ft. deep, indicated, with one exception, excellent rock, chiefly sandstone and shale, without water-bearing seams. However, one boring penetrated excellent sandstone and shale for a distance of 85 ft., at which point a vertical seam less than one inch in thickness was struck and followed for a distance of 9 ft. As soon as the diamond bit penetrated the seam, a large flow of water came to the surface and rose in a pipe 10 ft. above the surface, thus indicating a seam in which the water was under a high head. The water, which afterwards was found to be impregnated with sulfur, continued to flow after the boring was completed and flows today, presenting all the aspects of a sulfur spring. The core, when removed from the core-barrel, showed that the diamond bit had struck the vertical seam in such a way as to core from both sides of the seam. The core itself contained crystals of iron pyrites on those surfaces which had been exposed to the action of the water. This seam would probably have been of little importance because of the great overlying thickness of excellent rock.

The location of the part of the dam to the north of the Esopus lay along the drumlin. Borings, located in general over the drumlin, revealed the presence of the preglacial gorge in the bed-rock at an elevation of 80 ft. lower than and at a distance of 2 000 ft. from the present gorge of the Esopus. If the borings had indicated a compact and impervious earth from the surface down to the bottom of the preglacial gorge, the site would have been perfectly satisfactory for a dam, but the borings showed the gorge to be filled with a deposit 100 to 150 ft. in thickness of water-bearing sand, which was covered with compact, impervious earth 50 to 100 ft. thick extending from the sand to the surface. Evidence that the sand deposit was porous was furnisht in different ways. Several borings penetrating the strata of sand emitted a gas. In one boring after it had been completed for several weeks and in which the casing had been left, could be heard the sound, apparently, of running water. In general water was lost whenever the borings penetrated the sand. In addition to the borings a shaft was sunk near the site of the preglacial gorge as located by the borings; the sinking of the shaft was carried on without great difficulty thru the compact, impervious material, until a depth of 87 ft. was reacht, at which depth quantities of water, about 10 gals. per min., rusht into the shaft from the porous strata of sand. This rendered necessary the installation of a steam pump, which, after the shaft had been excavated a few feet deeper, could not remove the 100 gals. per min. of water then running into the shaft. A second pump was installed and a little later a third pump, 160 gals. of water per minute being the maximum quantity removed



Beaver Kill Dikes.—West Dike Site.

from the shaft. Finally at a depth of 114 ft. it became necessary to abandon the shaft altogether on account of the great quantity of water. A core-wall, founded on the solid bed-rock and extending thru the sand strata across the preglacial gorge, would have rendered the dam site perfectly safe, but such a core-wall was prohibitiv on account of the great cost of its construction. Accordingly it was concluded that the Tongore dam site was favorable for the construction of a dam only if a very deep and costly core-wall were constructed with its foundations on bed-rock.

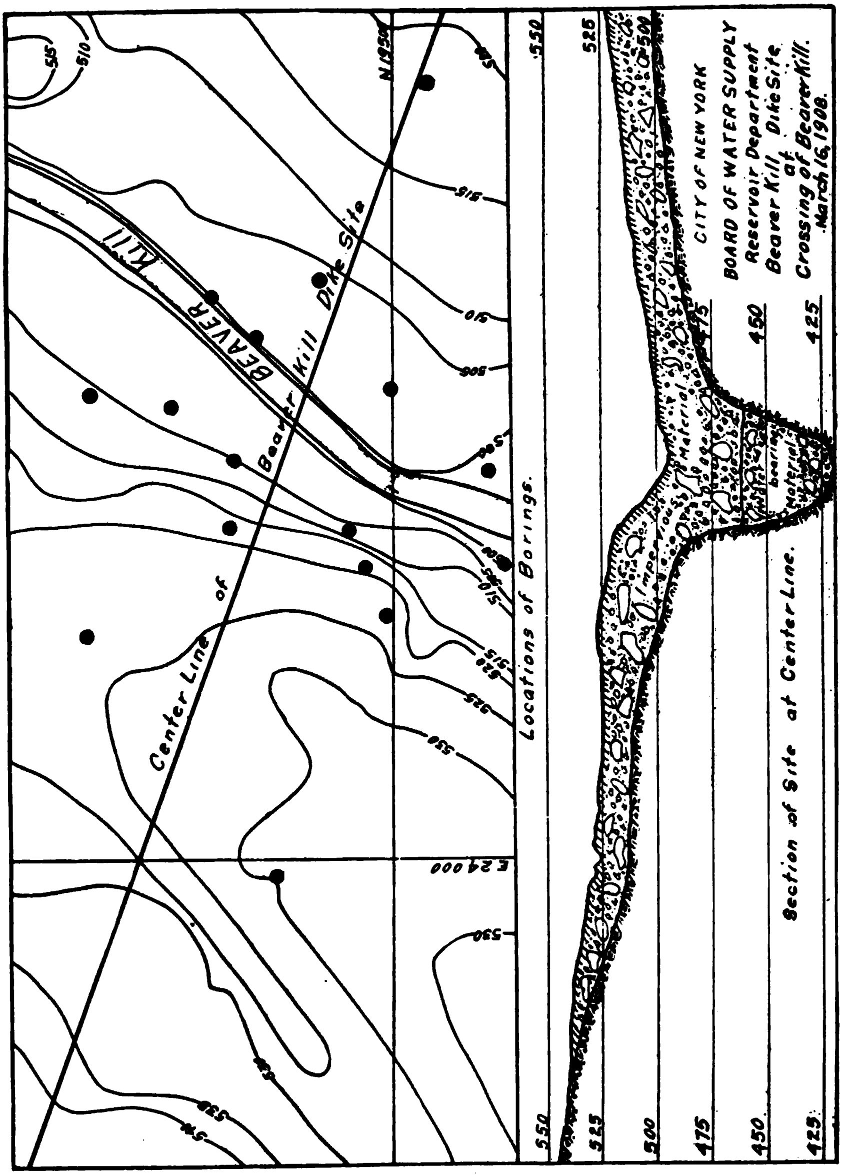
The dam site for the Ashokan Reservoir at Olive Bridge is divided into two parts, the Olive Bridge dam site and the Beaver Kill dikes site. The centerline of the Olive Bridge dam site, nearly one mile in length, extended from a hill situated on the south bank of Esopus Creek, across the Esopus, which here runs thru a gorge 50 ft. deep in the bed-rock, and terminated in a drumlin known as Winchell Hill, situated on the north side of Esopus Creek. The subsurface investigation of the Olive Bridge dam site required 150 borings aggregating 11 500 lin. ft., costing about $41 000, and a shaft 166 ft. deep, costing $14 400.

The borings on the south side of Esopus Creek showed the bed-rock to be covered at no point by a depth of earth exceeding 40 ft., the average depth being about 15 ft. Here an earth dike with core-wall extending to bed-rock will be constructed. The foundations for the 1 000 ft. length of masonry dam 210 ft. high to be bilt across the gorge of the Esopus will make no trouble. The presence of a few seams a few feet deep in the bed-rock will be overcome, either by excavating the bed-rock down to a point below the seams where the bed-rock is of good quality, or by drilling holes, and thru these grouting up the seams. On the north side of the Esopus, as at the Tongore dam site, borings located a preglacial gorge in the bed-rock, its bed being at an elevation of 50 ft. below, and at a distance to the north of 1 200 ft. from the present bed of the Esopus. Contrary to the subsurface conditions, as determined at the Tongore dam site, no bodies of sand were found to exist along the dam site, and borings indicated a compact and impervious earth to be the prevailing material. A shaft sunk near the site of the preglacial gorge, as located by borings, was, after some difficulty, excavated to the bed-rock, which at that point was covered by earth to a depth of 166 ft. There was absolutely no connection between the water-levels in the various borings; this fact indicated the presence of impervious material and the absence of all water-bearing strata. Accordingly the earth section of the Olive Bridge dam lying to the north of the masonry section will be constructed with core-wall extending about 20 ft. into the earth. Thus the site for the Olive Bridge dam for both earth and masonry sections was accepted as very satisfactory, the quality of the rock being in general excellent and the earth far more compact and impervious than at the Tongore dam site.

The centerline of the site for the Beaver Kill dikes, beginning at the above mentioned Winehell Hill, extended to the east a distance of nearly three miles. The investigation of the site required 71 borings aggregating 5 500 ft. in depth, costing $19 300, and a shaft 73 ft. deep, costing $4 700. The borings indicated an average depth of 30 ft. of compact, impervious earth overlying rock of excellent quality. At the west end of the Beaver Kill dikes site, near Winchell Hill, borings penetrating earth to a maximum depth of 250 ft. before striking the bed-rock, disclosed the presence of another preglacial gorge. However, this difficulty was overcome by shifting the centerline a short distance, thus avoiding the gorge and making it possible to found the core-wall of the earth dike upon bed-rock. Insufficient borings were made to determin either the definit location of the gorge, its nature, or whether it was the preglacial gorge of the Esopus or of some other stream; the lowest bed-rock elevation determined by borings was about 100 ft. lower than the present bed of the Esopus at the site of the Olive Bridge dam.

Another difficulty was encountered at a point where the proposed centerline of the dikes was to cross the Beaver Kill, a small stream 30 ft. wide and 2 ft. deep, tributary to the Esopus. Here borings definitly located in the rock, a preglacial gorge 150 ft. wide, its bed being 80 ft. below the present bed of the Beaver Kill, and lying in places directly under the present stream. This gorge is entirely filled with glacial drift, which consists here chiefly of a water-bearing mass of boulders, small broken stones with a little clay and sand. The water-levels in the borings were many feet below the present bed of the Beaver Kill. Experiments to determin the porosity of the material were carried on. Water in large quantities was

PLATE 14.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MALLETT ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Beaver Kill Dikes at Crossing of the Beaver Kill.

poured or pumpt into the casings, and in several casings the water ran off into the earth as fast as poured or pumpt into the casings. All this data indicated such a porous material that a core-wall was designed to extend to the bottom of the preglacial gorge, so as to prevent the water in the reservoir from forcing its way thru the porous material and beneath the earth dike. Near the middle of the dikes site, a shaft was sunk, which penetrated compact, impervious earth. The shaft, after it had been decided unnecessary to excavate deeper, was abandoned at a depth of 74 ft. Accordingly the proposed site of the Beaver Kill dikes, after the two above mentioned difficulties, one at the west end of the dikes site and the other at the Beaver Kill crossing, had been solved, was accepted as satisfactory, and a core-wall designed to extend to a depth in the earth of about 20 feet, and as deep as 40 ft. if found necessary, with the exception of the Beaver Kill preglacial gorge.

Borings indicated no general stratification of the earth about the Ashokan Reservoir but a compact, impervious earth containing large numbers of boulders. Geological reasoning alone, without the aid of borings, could furnish information concerning subsurface conditions only in general, and not in sufficient detail to be of greater value than as a rough guide as to the best methods in obtaining the details. Altho the bed-rock presents in general an approximately horizontal stratification, the borings indicate in general no definit and extensiv strata of either of the two predominating rocks, shale and sandstone, the two being indefinitly mixt. Borings pierced no boulders measuring more than 6 ft., but many boulders far larger are to be found on the surface. The boulders encountered were in general much harder than the nativ bed-rock, the diamond bit producing excellent core without seams; the presence of hard boulders without seams lies in the survival of the fittest, the soft and seamy boulders being ground to powder by the glaciers. A complicated system of preglacial drainage has been indicated by the results of the borings, but the borings have been too few to warrant definit conclusions. The Olive Bridge dam site for the Ashokan Reservoir was chosen in preference to the Tongore dam site chiefly because of more satisfactory subsurface conditions. In the location of the Beaver Kill dikes site, borings in general showed the subsurface conditions to be so satisfactory that the one point to be considered was the surface topography.

NORTHERN AQUEDUCT DEPARTMENT.

BY MR. ROBERT RIDGWAY,* MEMBER OF THE SOCIETY.

GENERAL.

The Northern Aqueduct Department, one of the five field departments into which the work of the Board of Water Supply will be divided, includes that portion of the Catskill Aqueduct between the Ashokan Reservoir and the Croton watershed, and has a length of 60¼ miles. It connects with the Reservoir Department on the north and with the Southern Aqueduct Department on the south. Its location with reference to the adjacent departments and to the general topography of the region is shown on Plate 15.

The work assigned to this department is the location and construction of the aqueduct to the Croton watershed, so that Catskill water may be delivered into Croton Lake at the earliest practicable date, and before the completion of the works nearer the city. In his report to the Board of Water Supply on October 7th, 1905, the Chief Engineer, Mr. J. Waldo Smith, Member of the Society, called attention to the fact that the combined capacity of the old and new Croton aqueducts is in excess of the yield of that watershed in a dry year. If, at such a time, the deficiency can be supplied from Catskill sources and the full flow maintained in the aqueducts, the danger of a water famine in the parts of the city supplied with Croton water will be averted. The completion of the work in this department as soon as it is possible to do so is therefore highly important. It should be remembered that every foot of the condit must be constructed before use can be made of any part of it.

Attention is called to the extraordinary size of this aqueduct as an engineering structure. Where cut and cover construction is used the condit will have a horseshoe section 17 ft. high by 17 ft. 6 in. in width. A view of this section is shown on Plate 16, which gives a better idea of the size than any description can do. This section is approximately 3½ ft. higher and 4 ft. wider than the normal section of the new Croton aqueduct tunnel. The capacity of the latter is about 300 m. g. d. while that of the Catskill Aqueduct in the Northern Aqueduct Department is about 600 m. g. d. In tunnels the section is somewhat smaller due to the greater slope allowed.

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* Department Engineer, Northern Aqueduct Department, Board of Water Supply.

The aqueduct location as now fixt is indicated on the map, Plate 17, by a heavy line. Before this definit line was laid down on the ground, a careful study was made of all the general routes which showed any promise of being feasible. As an indication of the extent of country investigated and the work involved in these studies, attention is invited to the map which shows most of the different routes considered. (See Plate 17.) It will be seen that the extreme lines cross the Hudson River over twenty miles apart. The locations were first studied on the topographical map of the United States Geological Survey, and those which seemed to require it were further studied in the field. In many cases stadia or plane table surveys were made, and the topography plotted on scales from four hundred to one hundred feet to the inch. Comparisons were then made of the different routes, the most important factors considered being economy and speed of construction, and safety in operation and maintenance. After careful consideration one after another of the routes was eliminated and the present one adopted as the best, all things considered. In connection with these preliminary surveys it is interesting to note that 57 000 acres were covered by the topographical surveys. The accomplishment of this work in a short time was possible only because of the loyal support of the engineers of the department and their subordinates, who cheerfully responded to every demand made upon them. Their zealous attention to and interest in their duties has been the subject of much favorable comment from those who have had the privilege of observing their work.

The United States Geological Survey maps mentioned were of great assistance in the preliminary work, and it is impossible to estimate how much time and money were saved to the city because they were available. The broad area covered by them made it possible to review all possible routes without extensiv investigations of every one of them in the field, so that studies were concentrated on those most feasible. If they, or similar maps, had not existed there would always have been a dout whether the route selected was the best one. It is a pleasure to testify to their general accuracy. In fact, it is surprizing how few errors they contain, when the small amount of money expended for them by the State and National governments is considered.

The ideal location would be one where the aqueduct would be constructed in open cut for its entire length on the hydraulic gradient, and on a direct line. Open cut construction, or cut and cover, as it is called, was therefore sought. Such an ideal location however was manifestly impossible to find, and efforts were devoted to ascertaining the one which would give the smallest percentage of tunnel at hydraulic grade and siphon below it, without undue increase in the length of the line. It is obvious that where the condit is constructed below the grade it must be strengthened to withstand the increast pressure, thus adding largely to its cost and to the difficulties of construction, operation and maintenance. This was kept in mind in the studies mentioned.

For the aqueduct at grade the cut and cover type of construction is preferred, because it can be more economically and rapidly constructed than a tunnel, which is only used where going thru a hill, instead of around it, cuts off enough length to effect a saving in cost. The aqueduct as now located is divided as follows:—

Aqueduct at grade in cut and cover....	36.35 miles =	60%
Aqueduct at grade in tunnel..........	6.66 miles =	11%
Aqueduct below grade in siphon.......	17.25 miles =	29%
Total...................	60.26 miles =	100%

The deepest depression encountered is the gorge of the Hudson River, the main drainage channel of the region, which, of course, must be crost with any location that could be adopted. An inspection of the map shows that west of the river the general direction of the line is necessarily across the drainage of the country and in addition to three of the minor streams, three wide valleys, the Rondout, the Wallkill and the Moodna, will require siphons each from 3½ to 4½ miles long. East of the river also several tributaries of the Hudson must be crost by siphons from 600 ft. to 1½ miles in length. The following table showing the length of all of the siphons of the department, arranged in geographical order from north to south, with the probable type of construction and the approximate length of each.

Name.	Type of Construction.	Length.
Esopus	Steel Pipe	1 850 ft.
Tongore	Steel Pipe	700 "
Rondout	Rock Tunnel	23 610 "
Wallkill	Rock Tunnel	23 400 "
Washington Square	Steel Pipe	3 550 "
Moodna	Rock Tunnel	19 800 "
Hudson River	Rock Tunnel	4 450 "
Foundry Brook	Steel Pipe	3 800 "
Indian Brook	Steel Pipe	600 "
Sprout Brook	Steel Pipe	2 270 "
Peekskill Creek	Steel Pipe	7 040 "
Total		91 070 "

It is possible to cross the two smallest of these valleys by means of a viaduct at grade, but the higher cost of this construction and the trouble it might be expected to give in maintenance led to the rejection of this type. Several other types have been considered, notably:

1. Deep tunnel in rock.
2. Steel pipes.
3. Reinforced concrete pipe.

Of these, the deep tunnel is preferred where the rock underlying the valley is not too deep or of too uncertain a character, because it is cheaper to construct, and gives greater assurance of safety and durability. This is the construction used so successfully in the New Croton Aqueduct, between shaft 19½, north of Jerome Park Reservoir, and the gate house at One Hundred and Thirty-fifth Street and Convent Avenue, including the tunnel under the Harlem River, which was driven at a depth of 300 ft. below tide. The pressures, however, in that tunnel are far less than those to be provided for in the Catskill siphon tunnels.

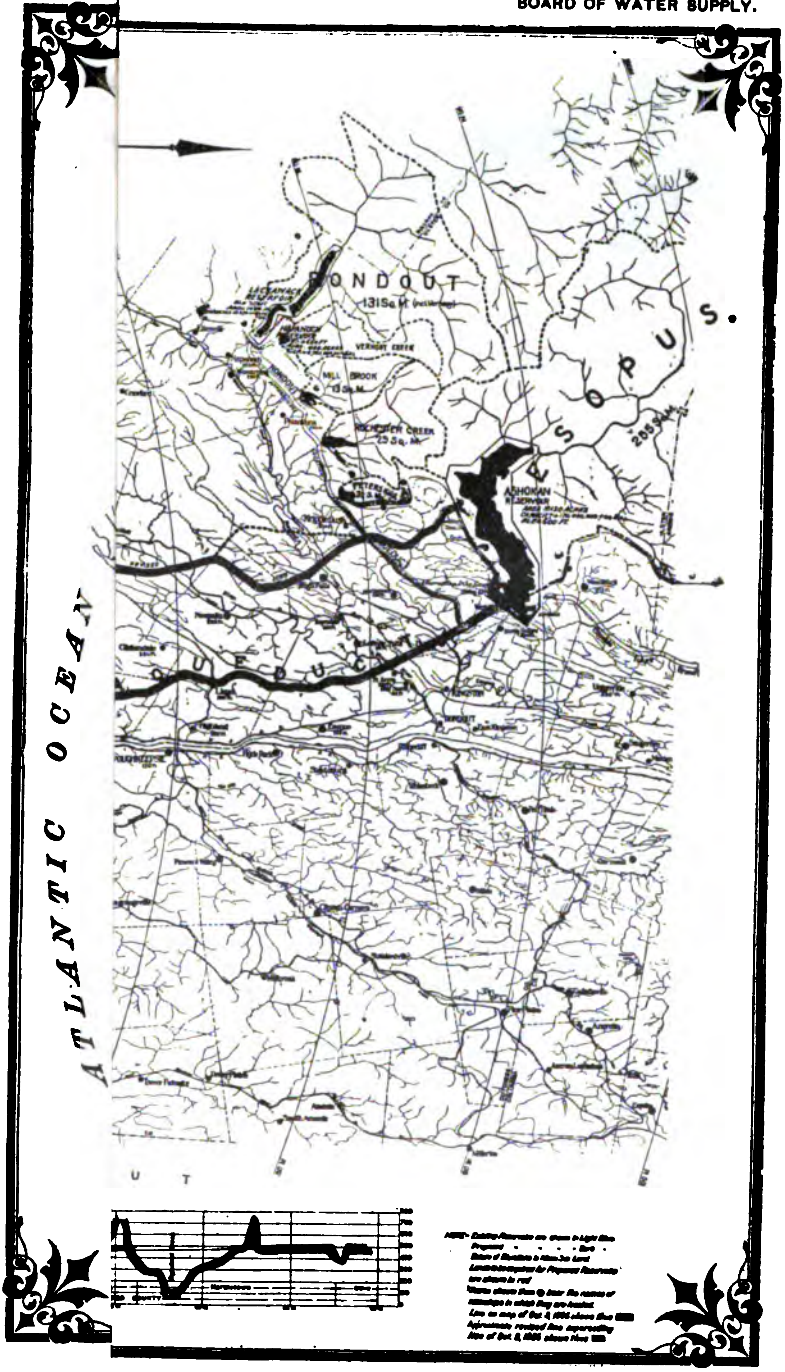
Experiments have been made with reinforced concrete pipes, with a view to adopting this form of construction for some of the shallow depressions, in place of steel pipes, if the results prove favorable. A number of 5-ft. pipes were made and tested in the yard at the foot of West Seventy-ninth Street, and at Hunter's Brook, at the south end of the Department, an experimental pipe 11 ft. in diameter and 210 ft. long was constructed last season, and is to be tested under varying pressures during the coming spring. The results of these tests will determin to what extent this type of structure will be used, and, if successful, the pipe already bilt at Hunter's Brook will form part of the aqueduct.

Before taking up in detail the underground investigations for the siphon tunnels, some remarks about the geology of the region are pertinent, and I would like to quote the following by Assistant Engineer James F. Sanborn, Member of the Society:

> "Broadly considered, the whole region traversed by the aqueduct from the Catskills to New York is known to geologists as the Appalachian Valley, tho occupied in part by mountain ridges. The general trend of this valley region is northeast and southwest, extending parallel with the great Atlantic seacoast from New York to Alabama.
>
> "All the great faults of the region run parallel with the mountains and valleys, northeast and southwest, and are the result of compressiv forces connected with the elevation of the continent above the sea floor. The rocks have been comprest until they either folded up, or shoved up one bed over another, just as the muck in a swamp buckles up into ridges when loaded with an embankment."

At each siphon, except a few of the smaller ones, extensiv investigations by means of borings were necessary before the definit location of the aqueduct or the type of structure could be determined. The services of geologists were enlisted from time to time to examin and report on the conditions in the light of data obtained from the investigations, and their expert advice has been of great assistance in reaching a decision in each case. In all of the larger valleys there exist preglacial gorges, worn in the bedrock by ancient streams, generally maskt by such a heavy cover of drift that their location, depth and extent could only be ascertained by the most careful search with core drills. It was early found that wash borings were utterly unreliable for this work, as they could not penetrate the boulder ground, and the only information they gave

PLATE 15.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



was of a negativ character. I will quote again from Mr. Sanborn regarding these buried gorges:

> "The existence of such a great number of deep gorges in the bedrock, extending far below the present drainage level, has long been known to geologists. It is certain that the original climatic and topographic conditions of this region, when these buried gorges were formed, were quite different from those existing at the present day. Not only was the eastern shore of North America at a much higher level above the sea than at present, so high that the region about Manhattan was a mountain area, but it is also regarded as probable that desert conditions prevailed, and the naked bedrock was everywhere exposed.
>
> "Under such conditions the streams cut deep channels along the main valleys. Then came the great ice invasion, bringing from the north an ice sheet hundreds, and perhaps thousands, of feet thick. This ice moved slowly, picking up great quantities of loose sand and rock.
>
> "At the same time a great settlement or subsidence of the eastern coast took place, and the valleys were all submerged below sea level. The valley of the Hudson River is still occupied by the sea, which stretches inland to Albany, 150 miles from the present coast line.
>
> "When finally the climate grew warm enough to cause the ice filling the valleys to melt, its burden of sand, clay and boulders was deposited, filling all the old stream channels and forming great dams and fills. These deposits of earth left by the ice so altered the surface of the country that in many cases the present drainage runs in a direction opposit to or across the original drainage, and the exact position of the old channel bears no relation to the location of the stream as we find it."

It is essential that a siphon tunnel must be deep in sound rock, on account of the great hydrostatic pressure to be considered. It will be seen then that the elevation at which such a tunnel should be constructed is fixt generally by the depths of the gorges.

The latter in all of the larger valleys have now been definitely determined, with the single exception of the Hudson River, where the difficulties of carrying on the explorations have been exceptionally great, as will be described later.

While the explorations of the preglacial gorges and the determination of the rock profile for the entire length of each siphon have been of primary importance, it has likewise been necessary to investigate carefully the general geologic conditions. Twelve formations of rock are met with in this department, as follows

Name of Stratum.	Kind of Rock.	Approximate Thickness.
	DEVONIAN.	
Hamilton	Flags and shaly sandstones.	Very thick
Onondaga	Blue limestone	150 ft.
Esopus	Shales	800 ft.
Oriskany	Sandstone with fossils	5 ft. to 10 ft.
	SILURIAN.	
Helderberg	Limestone	500 ft.
Manlius	Limestone—Cement Beds	80 ft.
Binnewater	Sandstone	50 ft.
High Falls	Red Shale	60 ft.
Shawangunk	Grit or quartzite	250 ft. to 300 ft.
	ORDOVICIAN.	
Hudson River	Slates and sandstones	Several thousand ft.
Wappinger	Limestone	1 000 ft.
	CAMBRIAN.	
Potsdam	Sandstone or quartzite	700 ft.
	ARCHAEAN.	
Metamorphic and igneous	Granit, Gneiss, Schist	Very thick.

All but two of these formations must be penetrated by the siphon tunnels. Nearly all of them are good rocks to tunnel and their characteristics are well known to tunnel contractors or miners. There are exceptions however to be noted later.

To date, the total length of wash borings made for the work is 51 255 ft., and of core borings, 55 774 ft., making a total of 107 029 ft., or 20.27 miles. This work was done by ten contractors, under 23 agreements and contracts, and by a small force employed directly by the Board. The borings range in depth from a few feet to a maximum of 656 ft., the latter hole being in the Rondout Valley. The deepest hole made in the Hudson River to date was 617 ft. deep, measured from the river surface.

The investigations of the Board have added much to the knowledge of the local geology and the information gained should prove of value and great interest to geologists generally.

BORING METHODS AND MACHINES.

The material drilled in the explorations of the Northern Aqueduct Department may be divided into two general classes: (1) Surface. (2) Rock.

The surface, or glacial material, consists of varying mixtures of sand, clay, gravel and boulders. This material often covers the rock to a depth of several hundred feet. The rock over the whole department may be regarded as distinctly hard—that is, it is not of a quality to be excavated without blasting.

In many respects, boring thru earth, or "surface," is more difficult than boring thru rock. If the rock is of a uniform quality, a progress of 10 to 30 ft. a day can often be maintained, but the presence of a gravel bed or boulder in the "surface" material, may bring on troubles which cause a delay of weeks in progressing a few feet.

The difficulties of boring in rock are mostly due to the occurrence of seams, caves, or material so soft that the walls of the hole cave in. In a few cases where rocks are extremely hard, the diamonds and other cutting agents wear away rapidly, but in general the troubles in rock are due to the presence of soft spots.

While the deep "surface" holes are usually the hardest to drill, under some conditions they are very easy. In sand or clay free from boulders, the holes often go down with astonishing speed. In certain cases, 150 ft. a day has been made, and a hole over 200 ft. deep to rock finisht in two or three days. Again a hole of the same depth in heavy gravel or boulder ground usually takes six or seven weeks. The deeper such a hole goes, the harder it becomes to drill it. The experience in the Northern Aqueduct Department indicates that in the material encountered more rapid and consistent progress can be made in drilling rock than in drilling surface material.

There are four general types of drilling machines:

1. Wash Drills.
2. Spudding Machines, or Churn Drills.
3. Diamond Drills.
4. Calyx, or Shot Drills.

The first two are used in drilling surface material, and the last three for drilling in rock. There are a great number of makes of each type of machine, and many drilling rigs use a combination of drilling methods, depending upon the ground penetrated.

WASH DRILLS.

The object of a wash boring is to get a casing pipe down thru the soft surface material to rock. The rig consists of a derrick and winding drum, operated by hand or by a steam engine. The hand rigs have limited penetration, except in very easy ground, and a small boulder or cobblestone will stop the boring. The heavy steam machines for drilling thru several hundred feet of glacial drift in exploring for rock, are used in connection with diamond or shot drills.

The casing is put down by washing up the sand and clay at the bottom end, and driving it into the cavity thus formed. The ground is loosened by means of a line of drill rods or 1-in. pipe working inside the casing. This wash pipe carries a chopping bit at the lower end, and the line of rods is raised and lowered with a churning motion by means of the hoister. The cuttings are washt up inside of the casing by a stream of water constantly forced down by a steam pump thru the inside of the wash pipe.

The casing is used in lengths of from 6 ft. to 10 ft., connected by couplings, and is driven by means of a heavy weight operated by the hoister, after the manner of a pile. As a general rule, it is not possible to put the casing down easily much over 100 ft. on account of the skin friction of the outside material. When the limit of easy driving is reacht, a smaller size is "telescoped" inside the first casing until it is in turn stopt by the friction. In some cases 6-in. casing is started, then 4-in., 2½-in., and occasionally 1⅝-in. casing is used in going down about 250 ft. Ordinarily in deep holes up to 350 ft. three sizes of casing are used. In driving casing a heavy blow should not be struck by dropping the weight a great distance, but the casing is tapt down by light, repeated blows, which loosen the outside sand and break the skin friction. At the same time, the casing is turned by hand with chain tongs, and the wash pipe is kept working.

In sinking casing in sandy ground, the progress is usually very fast, as the material loosened by the chopping bit can be rapidly washt up by the stream of water forced down the wash pipe. In such ground the casing sinks of its own weight, and does not have to be driven all the time. In very fine loose sand the wash pipe is often dispensed with; the pump is connected directly with the top of the casing so that the water is forced to the bottom of the latter, and comes up on the outside while the casing is constantly turned with chain tongs. This operation is called "washing down" the casing. Where gravel is encountered, progress is much slower, as the stones have to be first chopt up and then the cuttings washt out. In porous ground it is necessary to keep the casing driven down very close to the end of the wash pipe, or the water will all be lost in the ground instead of returning to the surface carrying the cuttings. In gravelly ground carrying cobbles, it is usually best to make sparing use of the wash pipe, as the fine sand is washt away, and a nest of cobblestones collects under the foot of the pipe.

When the stones or boulders are too large to be readily chopt up, dynamite is used to break them up or shoot them to one side. The slowest progress is made in such ground, as it is necessary to pull up the casing a few feet every time a shot is fired. When a large boulder is encountered, a hole is drilled thru it by the diamond bit, and dynamite used to break it up.

The best way to pull casing is not by a steady strain, but by tapping it upward with a heavy weight, as in driving. When the casing is stuck, it is pulled by putting a strain on it by means of two hydraulic jacks, and then tapping upward on it with the weight. It seems to require much more power to tap upward than downward. A weak machine can slowly lift a heavy weight a certain distance and let it drop by gravity, while the upward tap depends upon the direct upward pull of the machine aided somewhat by the momentum of the weight.

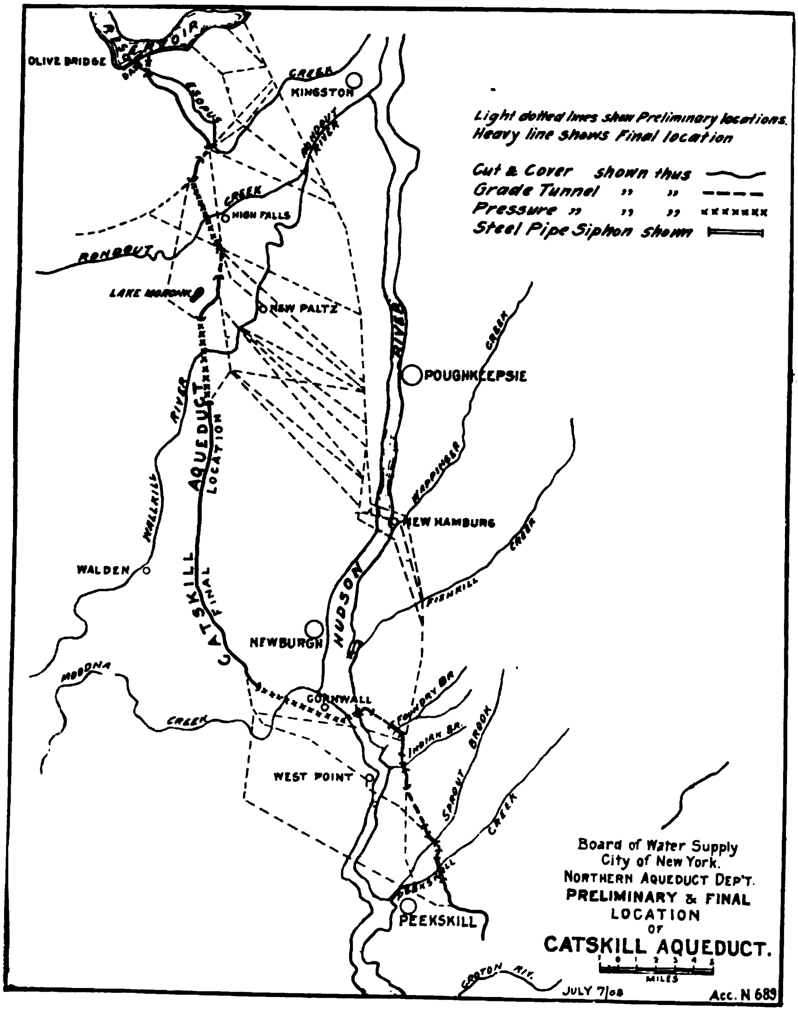
Troubles in Drilling Surface Material.

The principal troubles in drilling surface material arise when gravel or boulders are met. A boulder in sand under the bottom of the casing is a hard thing to remove. The sand washes up inside the casing, making it hard to chop the boulder. Even if the boulder is shot to one side, it is liable to follow the casing down, and drop into the hole washt out under the pipe. When dynamite is used it is lowered into the hole on top of the boulder. The casing is then raised to keep it from being broken by the explosion. The sand sometimes flows in as the casing is raised, and floats the dynamite up inside the pipe, which is broken by the shot. When this happens, a new hole has to be started. Dynamite in the ordinary stick form is used for blasting boulders. It is let down into the hole by means of the battery wire and exploded with a "magneto" battery. Experience seems to indicate that the grade of explosiv known as "gelatine" is more reliable in its action than dynamite, and that the liberal use of exploders, one to each stick, and of a powerful battery, is essential.

One trouble in dealing with boulders is the difficulty of exploding the dynamite. There seems to be some strange unexplained difficulty in setting off dynamite in the bottom of deep holes, which is usually attributed to the chilling of the explosiv. After a miss, the dynamite has often to be chopt out. This can be safely done in a hole as shallow as 30 ft. in depth. The failure of the dynamite to explode is sometimes due to a leakage of current occurring between the battery wires, which are surrounded by water in the hole, but sometimes the end is blown off a stick without exploding the whole of it. Even when the casing is pulled up high enough to clear the dynamite by several feet, the shock of the explosion communicated thru the water has been known to split the casing far above the boulder.

Gravel of varying size is one of the most difficult materials to penetrate. It often leads away the wash water, and also puts great strain upon the wash rods, due to wedging the bit and causing the rods to part. In such a case a conical recovering tap is let down on a line of rods and cuts a thread into the end of the broken pipe, so it can be raised. If a hole in the rods cannot be found by the inside tap, an outside recovering tap is let down, and a thread cut on the outside of the rods, so they can be pickt up. Gravel frequently causes the loss of a chopping bit, which is broken off by the great strain and twisting effect to which it is subjected. A lost chopping bit may cause no end of annoyance, as it blocks the bottom of the pipe, and cannot be easily pickt up with a fishing tool. The lost bit is treated like a boulder and blasted repeatedly to drive it to

PLATE 17.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



MAP SHOWING PRELIMINARY AND FINAL LOCATION OF CATSKILL AQUEDUCT.

one side. A chopping bit has been known to follow the casing down 40 or 50 ft. below the point where it was lost, giving trouble all the way.

The ground is often so soft and watery that fine sand flows up inside the casing, sometimes causing the wash pipe to become wedged fast, so that the casing has to be pulled up before the wash pipe can be removed. When the material is at all difficult, the wash boring machine should be equipt with a powerful pump and hoister. The lack of adequate equipment is the principal source of trouble with such rigs. A strong pump will make it possible to penetrate and wash out gravel where a weak one would be useless. A strong hoister is essential in driving out casing and in chopping gravel.

One great source of trouble is the parting and bending of casing, both in pulling and driving. This is due to the tendency to save money in the cost of material by using too light a pipe. The weight of casing known as "extra heavy" should always be used in bad ground. Moreover, the casing must not be driven too hard. It must be coaxed down, rather than forced. It is rather by a succession of light, rapid blows that casing and wash pipes are driven than by the use of great force.

CHURN DRILLS.

These machines are used for drilling in either glacial drift or rock. They are used extensivly in drilling wells for water, and were employed by the Board for exploring the depth of glacial deposits above the bedrock. They do not give a rock core like the shot and diamond drills, but the material comes to the surface in fine fragments. (See Plate 18; Fig. 1.)

The machine consists of an apparatus for raising and lowering, with a churning motion, a string of tools attacht to a rope. Only a small quantity of water is required to make a thick creamy batter of the rock as it is broken. Drilling is stopt and the hole bailed out from time to time by a sand pump, consisting of an iron pipe with a valve on the bottom, which is lowered into the hole.

The string of tools consists of a hardened steel chopping bit, screwed into a stem from 10 to 40 ft. long. A set of jars is attacht at the top of the stem, for jerking or jarring the bit loose when it sticks in the bottom of the hole. The entire string of tools used on holes about 400 ft. deep weighs about 1 000 lb.

This machine is cheap in operation, as only two men are needed when drilling in rock. When driving casing, four men are needed. As very little water is required, the churn drill has a great advantage where water is scarce, but is often at a great disadvantage in a wet hole, due to the fact that the cuttings are removed only at intervals.

DIAMOND DRILLS.

Diamond drills are used to take a sample or core of the rock penetrated. The machine consists of a geared spindle driven by hand or steam power which rotates a line of rods and feeds them down the hole. (See Plate 18; Fig. 2.) The cutting is done by the diamond bit screwed on the bottom of the line of rods. This bit has an annular form, and the diamonds are set in the soft metal around the edge, in such a manner as to cut a small clearance on the inside and outside. Eight stones are ordinarily used. Care is taken that the diamonds cut the whole area of rock at the bottom of the bit—otherwise the steel would be worn and the stones loosened.

As the bit cuts the rock the core passes up thru the center of the bit into the core barrel, an especially straight piece of pipe a little larger in diameter than the rods, where it is held by a spring. Water is pumpt down the rods to keep the diamonds cool, and to wash away the fine cuttings.

Black diamonds from Brazil are used for the bits. Before being put on the market the stones are crusht, and the large pieces with sharp edges selected. The size varies from one to two carats, worth from $40 to $90 a carat, according to size and quality. The stones vary greatly in grade, some wearing away rapidly, while others prove almost indestructible. A good set of stones well tried by use is often worth from $500 to $800.

TROUBLES WITH DIAMOND DRILLS.

If a seam in the rock carries away the water, the cuttings are liable to pack around the core barrel, or the bit may become wedged in an open crevice in the rock. In either case, the rods may be twisted off, and have to be fisht for by the recovering tap. There are a number of other devices for recovering rods, but at times they

PLATE 18.
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RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.

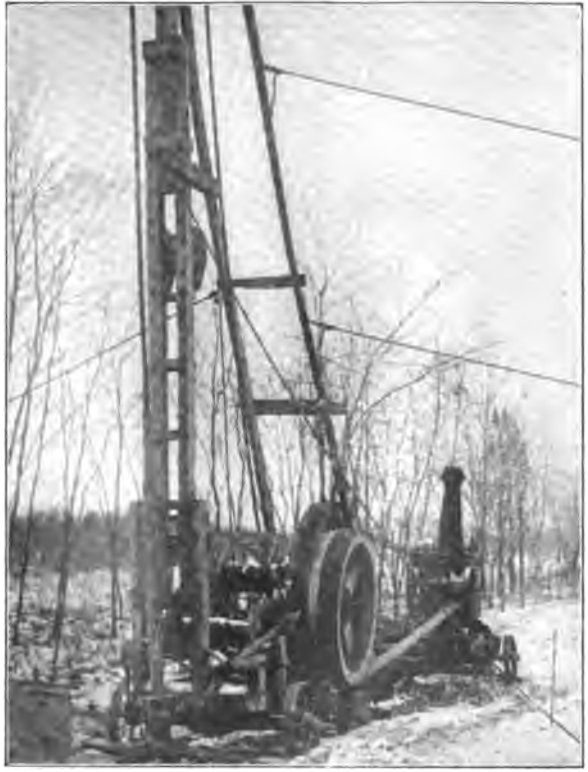

FIG. 1.—CHURN DRILL EXPLORING BURIED GORGE ON LINE OF MOODNA SIPHON TUNNEL NEAR VAILSGATE.

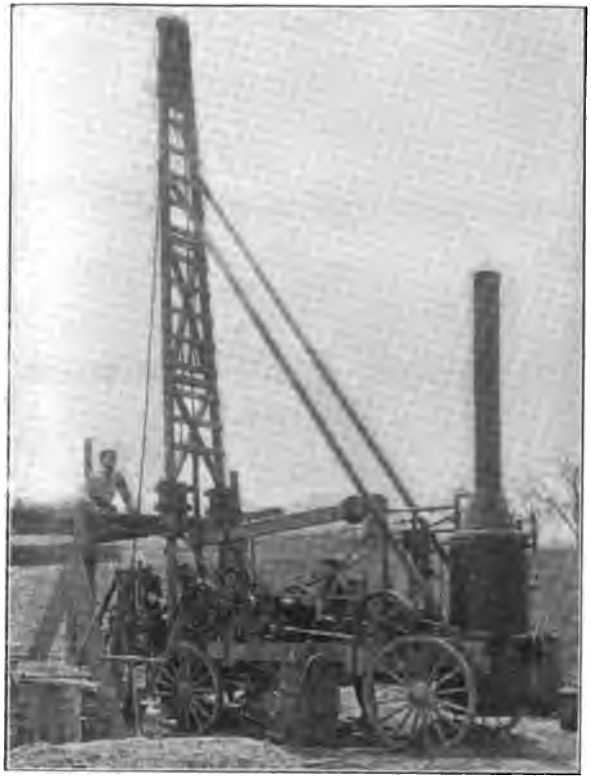

FIG. 2.—CHURN DRILL AND SULLIVAN BADGER DIAMOND DRILL, BILT AND OPERATED BY THE BOARD OF WATER SUPPLY.

all fail. A bit was lost on the Esopus division in a 20-ft. cave. The cave contained a stiff clay which at first gave support to the rods, but as it was washt away, the rods bowed out and broke off. The top of the broken rod was so much out of line that it could not be pickt up, and it was never recovered. The contractor asserted that the value of the lost bit was $1 000.

A great deal of heat is generated as the bit cuts. If for any reason the water does not get to the bit, and the boring continues, the diamonds will be burned and completely ruined. Therefore a drill runner watches the behavior of his pump, and the flow of water from the top of the casing.

If a bit is used too long, the steel is worn away from the diamonds so that the stones are torn out and ground up by the bit.

At times the cores in the core barrel break up, and pieces become wedged, causing the bit to bind. When this blocking occurs in very hard rock, diamonds are often torn out and shattered.

When a bit is lost in a crevice, it is sometimes necessary to ream out the hole with a larger bit and case the seam in order to recover the lost diamonds.

SHOT DRILLS.

The shot or calyx drill uses rods and core barrels similar to the diamond drill except that the core barrel is generally larger in proportion to the size of the rods. It is fitted with a bit at the lower end with a single large notch cut in it. Hardened steel shot is fed to this bit along with the water, and cutting is accomplisht by the grinding of the shot below the bit. The core barrel is provided at its upper end with a calyx extension, open at the top, equal in diameter to the core barrel. The calyx surrounds the rods, and acts as a receptacle for catching the fine cuttings. If sufficient water is used to bring the cuttings to the surface, it washes the shot away from under the bit. Therefore a small amount of water is used and the cuttings are allowed to wash up and collect within the calyx. They are in this way brought to the surface. When it is desired to bring the core to the surface it is grouted with coarse sand or gravel. A few handfuls of this material are poured into the rods and washt down. This sand or gravel becomes wedged between the core and core barrel and holds the core in the barrel.

Shot drills are good where there are uniform rocks to be bored such as Manhattan schist. They have been used on a large scale in New York to drill holes for plunger elevators. They seem to be less efficient in drilling stratified rocks of varying hardness. The progress on the Esopus Division of the work with them has been 2 or 3 ft. per day as compared with 10 to 20 ft. with diamond drills. There is one bed of rock there, the Shawangunk grit, 250 ft. or more thick, which the shot machine seems to be absolutely unable to penetrate. This rock is pure quartz conglomerate and contains seams in many cases having water flowing thru them. When the shot bit reaches one of these seams in the grit the shot is carried away and the bit is left to grind on the quartz. No steel however hard will make much impression on it by rotary action, altho it can be readily drilled by a percussion drill.

Interpretation of Boring Records.

To the engineer unused to such work it is difficult to judge whether a boring contract is being handled properly. The tendency is to magnify the difficulties encountered, when the trouble may lie with the contractor's methods or appliances. Months may be spent in gaining only a few feet at great labor, and anybody watching the operation might conclude that the difficulty was insurmountable. The substitution of a different machine or of men more efficient in this class of work means in nearly every case the successful completion of the boring. The experience of the drill runner is of course a very large factor in successful boring, but his experience alone cannot make up for inferior machines or equipment. Such troubles as the bending or breaking of the casing is frequently attributed to the difficult character of the ground, but the employment of heavy casing or proper machines will usually overcome the difficulty. The same considerations apply to borings in rock as in earth. A shot machine may be employed to do work for which it is entirely unsuited, or a small diamond drill, not of the hydraulic type, may be found inadequate for a certain rock. In one case it was found that a light machine could make only 2 ft. per day in the grit, whereas a hydraulic rig easily made about 10 ft.

As stated above, misleading conclusions are apt to be made from boring work and records. Where a boring machine is having great

PLATE 19.
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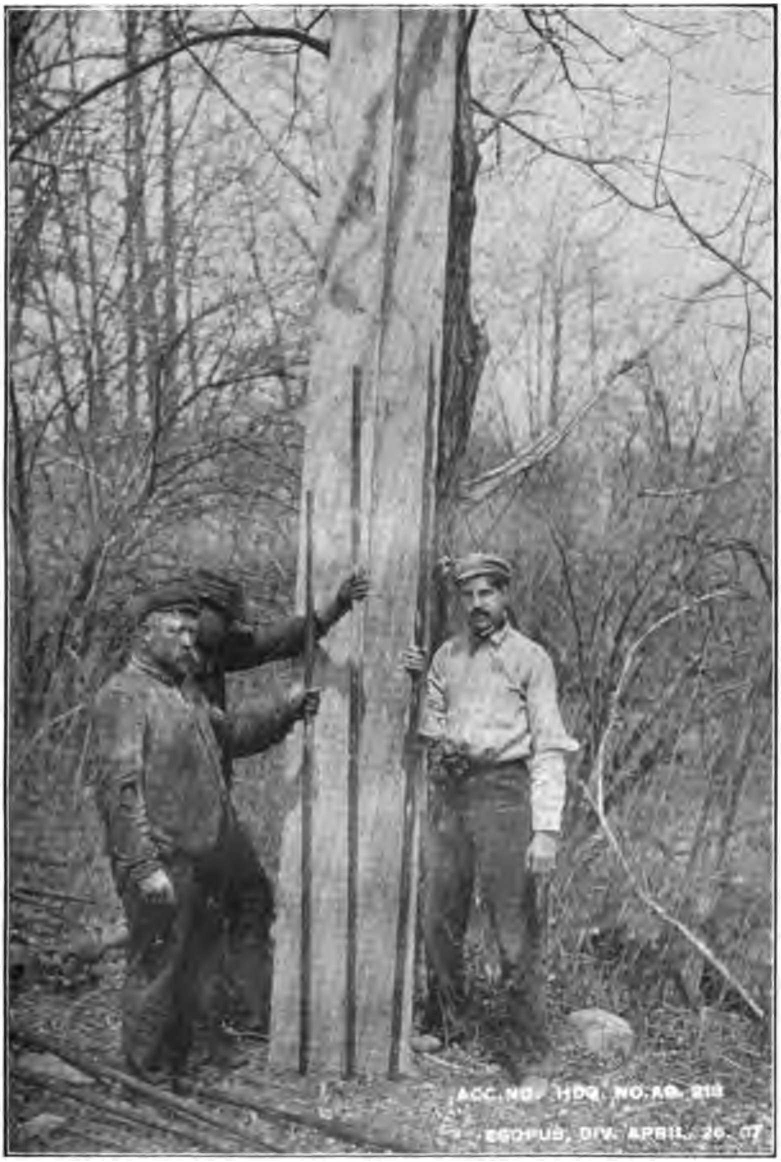
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



TEN-FOOT ROCK CORES, TAKEN BY THE BOARD OF WATER SUPPLY DIAMOND DRILLS.

trouble due to seams in the rock, one is apt to conclude that the rock itself is very hard, whereas such a conclusion may not follow at all. For instance a rock in which the strata are in a vertical position may be very difficult to bore with a diamond drill; such a rock is in just the right position for tunneling thru, as the layers will support themselves instead of caving in flat slabs, which might happen were the strata in a horizontal position. Seams in rock will bother a rotary drill greatly, whereas a percussion machine may readily penetrate it. Moreover a rock may be penetrated very easily by a rotary drill and not by a percussion machine.

Reliance cannot always be placed upon the percentage of core recovered from different rocks. These percentages are apt to vary according to the variety of drill and manner in which the machine is handled. The dip of the strata is an important factor; slate on edge is very easily tunneled into, but may yield a very low percentage of core, whereas material difficult to tunnel may give a high percentage of core.

It is most difficult properly to interpret wash boring samples. If clay or uniform sand is being penetrated the samples are all right, but in the majority of materials only the coarser particles are likely to be preserved unless great care is used. Where hardpan, composed of a large percentage of clay, is being penetrated in drilling, it will cause the loss of most of the clay in the wash water, so that the little material recovered is composed of sand and gravel. Such a sample may be labeled "Sand and Gravel" by the drillers, and an examination of the contents of the sample bottle will apparently bear out this erroneous conclusion.

The following is a description of the leading characteristics of the larger siphons and of the developments that led to the decision on the type of aqueduct structure to be used for each one. These descriptions have, in many cases, been prepared by Assistant Engineer Sanborn.

RONDOUT SIPHON.

The first of the large valleys to be crost by the aqueduct is that of the Rondout Creek, between the Catskills and the Shawangunk Mountains. The lowest point on the profile of this valley, where the aqueduct will cross, is the surface of Rondout Creek, some 300 ft. below the hydraulic grade line. A pipe line laid on the surface of the ground would therefore have to resist a pressure of about 130 lb. per sq. in., and the steel plates as designed would have to be 1 in. thick at this point. The width of the valley at the crossing is nearly 4½ miles.

On account of the great cost and perishable character of a pipe line, it was decided to cross this valley with a tunnel deep in the bed-rock. (See Plate 20.)

THE PINEBUSH GORGE.

From knowledge gained by borings made on a line previously surveyed at Hurley, eight miles northeast of the present line, it was suspected that a deep valley filled with glacial drift existed under the plains on the west side of the Rondout valley, at Pinebush, altho absolutely no evidence of such a bed-rock depression is to be seen on the surface.

The first borings undertaken were consequently located near the west end of the proposed tunnel for the purpose of discovering the maximum depth to bed-rock in this old gorge.

At Hurley the gorge extended to a depth of 70 ft. below sea level, so that it was expected that a depth nearly as great would be reacht at Pinebush. The geologists employed by the Board were particularly insistent upon a thoro survey of the bed-rock to make certain that no deep and narrow gorge escape discovery. The borings were therefore put down within 100 ft. of each other in the deepest part of the gorge, but the bottom of the old valley on this line extends but little below an elevation of 100 ft. above tide.

The ancient stream wore out its bed along a line between the hard and flinty Onondaga limestone and the softer stratified Hamilton shale, cutting against the edges of the latter beds.

It was first intended simply to locate the surface of the bed-rock, by drilling thru the glacial drift with heavy casing, and then taking a core with the diamond drill to make sure the bed-rock, and not a boulder, had been encountered. Many of the holes were driven over 250 ft. thru glacial drift, while only 25 or 30 ft. of core was taken with the diamond drill.

Several of the diamond drill holes, however, extend to a great depth in rock and disclose the interesting fact that a fault with a considerable vertical displacement occurs just under the ancient

PLATE 20.
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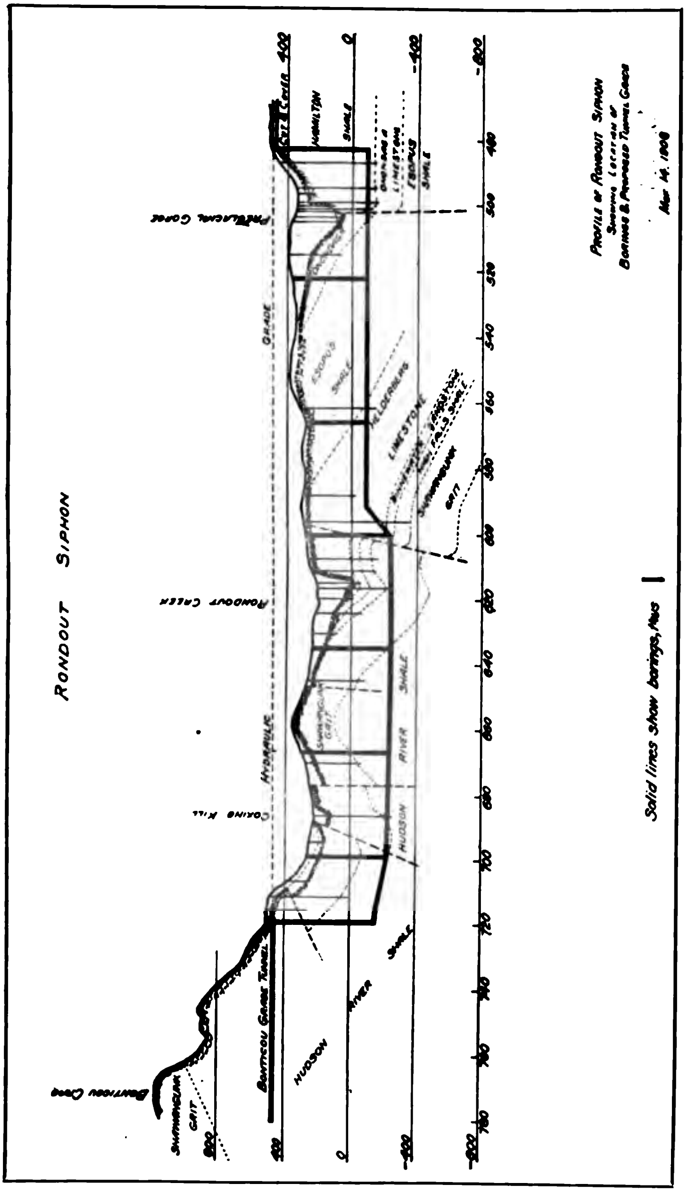
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



PROFILE OF RONDOUT SIPHON.

gorge. The cross-section shows that the bed of Onondaga limestone to the west of the buried gorge lies 130 ft. deeper than the same stratum where it formed the bed of the ancient stream.

These discoveries of the diamond drills show that the tunnel must be kept down very deep at the west end to provide sufficient bed-rock cover above the tunnel so that no danger of leakage of water occurs after the aqueduct is put in service. The grade finally adopted places the tunnel invert at elevation—100, which will cause the tunnel to pass thru the fault zone in such a way as probably to avoid the bed of Onondaga limestone.

THE RONDOUT GORGE.

Still another deep gorge completely filled with glacial drift was discovered under the hillside just west of Rondout Creek. The existence of this gorge was unsuspected even by the geologists. The drills show it to be similar in character to that at Pinebush, worn down along a resistant stratum against softer overlying layers. The west bank of the old gorge was a veritable cliff of limestone, overhanging in places as shown by one of the drill holes.

THE FAULT AT SHAFT 4.

A bed known as the Binnewater sandstone underlies the limestones west of Rondout Creek. To determin the leakage of water thru this porous bed, a deep hole 4 in. in diameter was put down with the shot drill on the proposed site of Shaft 4. This hole showed that a fold in the strata brought all the formations higher than had been expected. Still another hole farther to the west showed that the strata drop 220 ft. in a horizontal distance of only 650 ft., due to a fault, hitherto unsuspected. This hole, moreover, traversed a clay seam for a vertical distance of 30 ft., a still further evidence of extensiv displacement in the rocks.

THE SHAWANGUNK GRIT BED.

From a point near Rondout Creek, all the way to the base of the Shawangunk mountains at the east end of the siphon, the overlying shale and limestone beds have been removed, leaving the very thick and hard layer of white Shawangunk grit, which forms the floor of the valley for a distance of 1½ miles. This rock is made up of white quartz pebbles cemented together by silica, and the material is so hard it is used extensivly for millstones for grinding grist and cement rock. Holes drilled thru this "millstone rock," as it is termed locally, show its thickness to vary from 250 to 350 ft. Many of the drill holes show the grit to be full of seams carrying water, which flows to the surface. As an obstacle to tunneling, the grit bed is lookt upon with considerable distrust, both on account of its hardness, which would make slow progress and high cost, and on account of its brittle and seamy character and water-bearing qualities.

The great depth of the bedrock gorge at Rondout Creek, with its bottom just at sea level, throws the tunnel deep down into the grit bed. To avoid driving the tunnel for a great distance in this hard and brittle formation, the design adopted places the grade of the tunnel east of Rondout Creek at a depth of 250 ft. below sea level. This will locate the tunnel in the soft and easily excavated Hudson River shales which underlie the grit.

THE COXING KILL OVERTHRUST.

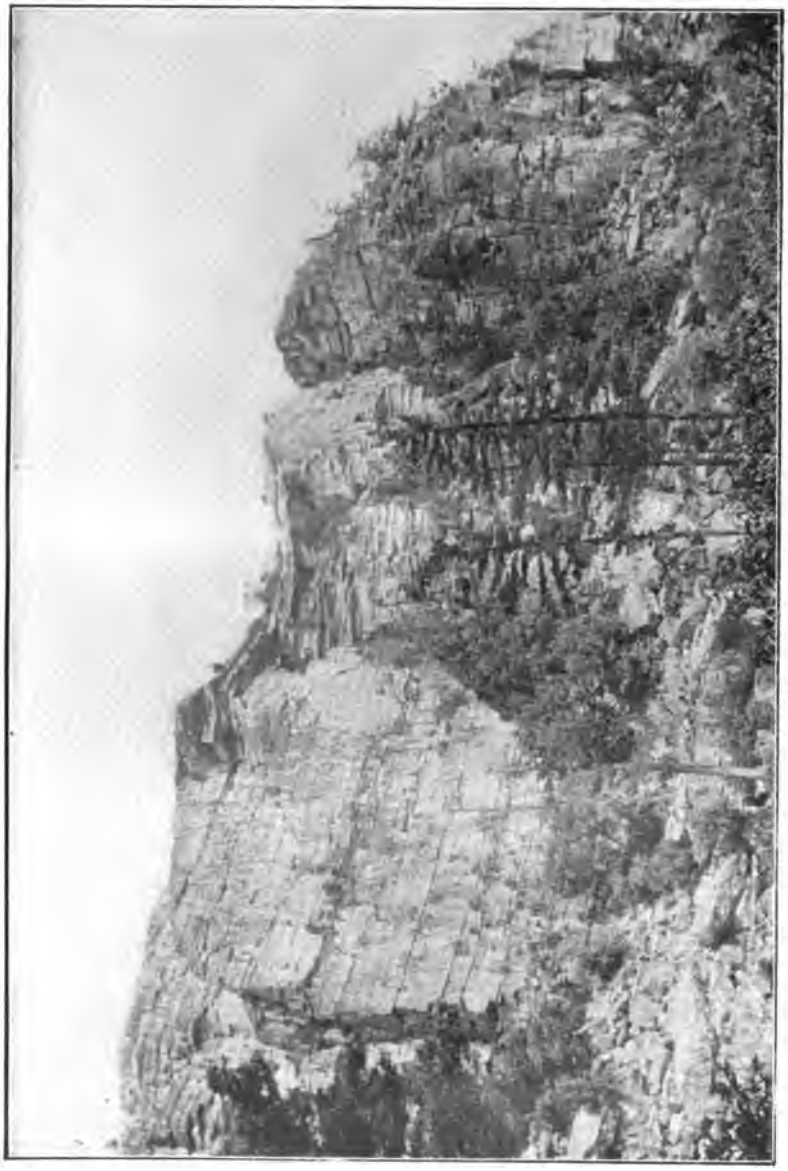
Drill holes thru the grit in the neighborhood of the Coxing Kill show a considerable local increase in the thickness of the bed at that point, due to an overthrust fault, as indicated on the profile. One of these holes developt a strong flow of water charged with hydrogen sulfide gas, which has been running at the rate of 10 gal. per min. for over a year.

THE SHAWANGUNK OVERTHRUST.

At the eastern end of this siphon, the Shawangunk mountain ridge rises far above hydraulic grade. (See Plate 20.) The rock on the surface is Hudson River shale, which belongs normally beneath the Shawangunk grit. Diamond drill holes show, however, that the shale has been overthrust upon the grit for a horizontal distance of 1 200 ft., so that a long wedge-shaped tung of grit lies buried by the superimposed shales.

This great overthrust, as well as the faults at Coxing Kill, at Shaft 4, and at the Pinebush gorge, all of great importance in affecting the tunnel location, were discovered only by the deep diamond-drill holes.

PLATE 21.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Bonticou Crag, Shawangunk Mountains, Beneath which the Catskill Aqueduct Will Run in a Grade Tunnel.

BORING METHODS.

At times as many as seven rigs were working in this valley. Most of the borings were made by the firm of Sprague & Henwood, of Scranton, Pa., by rigs which employed a tripod-derrick and hoister for driving the casing, and a Sullivan diamond drill rig for taking cores after the rock was reacht. This method seems to be the most effectiv of any employed by the contractors on the work in the department. The Board has one "steam rig" mounted on wheels, with boiler, pump, winding-drum and walking-beam for driving casing. A diamond drill is used in connection with it for drilling in rock. This rig works very well.

Where the surface material is over 200 ft. deep, as at Pinebush and at Rondout gorge, a large-sized casing is first put down as far as possible, then a smaller casing "telescoped" inside the first, and so on until the rock is reacht. Sprague & Henwood employ 5-in., 3-in. and 2-in. casing, while the Board uses 6-in., 4-in., 2½-in. and occasionally 1⅝-in. casing.

WALLKILL SIPHON.

On the east side of the Shawangunk Mountains the main drainage of the country is discharged thru the Wallkill Valley, which will be crost by the aqueduct in a bedrock tunnel, as in the case of the Rondout siphon. The length of this tunnel will be about 4½ miles, about the same length as the Rondout. (See Plate 22, Fig. 1.)

Several lines of borings were made across this valley to explore the ancient bedrock gorge. The first located at Springtown, eight miles north of the present line, showed a wide valley in the bedrock, extending to a depth of 80 ft. below sea level. Other lines farther to the south showed the buried gorge to be much narrower and shallower, until at the crossing finally adopted, the bottom of the ancient gorge was found to be at elevation +67. This is the lowest point in the bedrock profile and determins the maximum depth of the tunnel, which will have at this point a rock cover of about 150 ft.

The deep gorge is the most important geological feature controlling the design of this tunnel. Borings were made the full length of the tunnel line, 4½ miles, to determin the bedrock profile, which is deeply buried in glacial drift except in a few places. Most of the holes were relativly shallow, extending only a few feet into the bedrock, which everywhere consists of Hudson River shale and sandstone, easy material thru which to drive a tunnel, as the rock can be drilled rapidly, and will probably carry little water.

Boring Methods.

The material filling the deep gorge from Springtown to Libertyville is everywhere clay or fine sand, with relativly little gravel and very few boulders. This material was more easily drilled than the ground encountered elsewhere on the siphon.

For exploring the gorge both wash drills and diamond machines were used. The wash drills were very successful, especially in the clay, but were not reliable in any hard packt gravelly material, and were stopt altogether by small boulders.

The diamond drills equipt with means for driving heavy casing to bedrock were used everywhere along the final line. The rigs were similar to those used at the Rondout siphon.

MOODNA CREEK SIPHON.

The valley of Moodna Creek running nearly east and west, is crost by the aqueduct line near Cornwall. The tunnel will be about 3¾ miles long. The present stream, where it is crost by the center line, about two miles from the Hudson River, has cut down to an elevation of about 120 ft. above tide in the clay and boulder deposit left by the glacier. (See Plate 22, Fig. 2.)

The Deep Gorges.

Altho there is no evidence on the surface, a geological survey and the records of a deep well at Meadowbrook showed the probable existence of a preglacial gorge in the bedrock, deeply filled with drift. It was thought that this gorge probably occurred just north of the present creek, and borings were put down to discover the rock.

A great number of borings in the northwestern half of the line were necessary to develop the floor of this old valley, which lies at an elevation about 50 ft. below sea level. In fact, a double valley with a ridge of rock between was shown to exist. The borings had to penetrate a mass of drift 350 ft. thick overlying the bedrock, and completely filling the old valley for a width of a mile. This is the

PLATE 22.
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RIDGWAY ON SUBSURFACE
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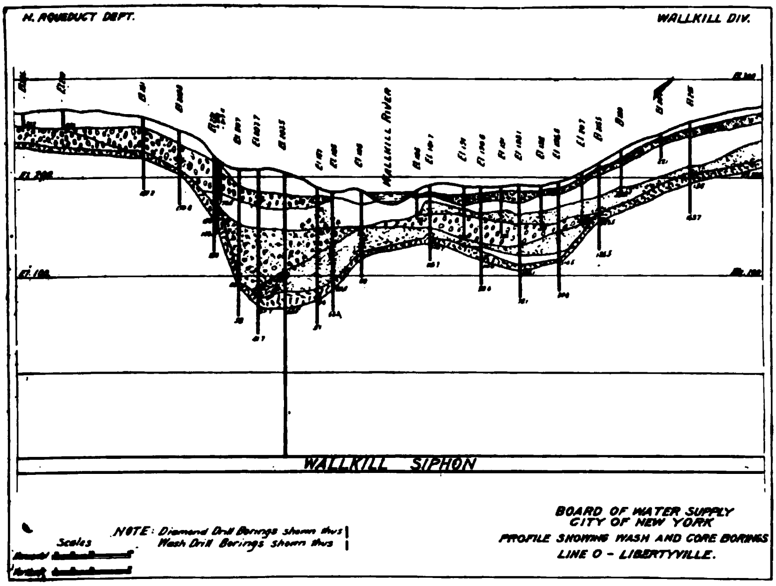

FIG. 1.—PROFILE OF BORINGS AT THE PREGLACIAL GORGE. WALLKILL SIPHON.

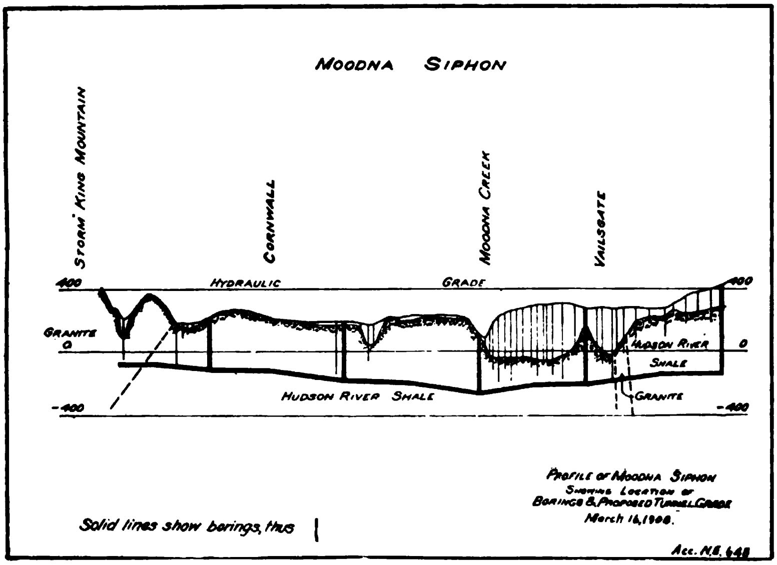

FIG. 2.—PROFILE OF MOODNA SIPHON TUNNEL, SHOWING BORINGS TO LOCATE ROCK IN PREGLACIAL VALLEY.

deepest covering of surface material encountered by the drills anywhere on the line, except in the bed of the Hudson River.

Because of the great depth to bedrock in the Hudson gorge near by, the geologists insisted strongly that the ancient Moodna Valley be thoroly explored, that no narrow gorge extending to a great depth below sea level escape notice. Borings were accordingly put within 150 ft. or 200 ft. of each other, but no deep cañon in the level floor of the valley was found.

It is decidedly surprizing to find the bottom of this valley cut by a large tributary stream, lying at least 550 ft. higher than the bedrock in the Hudson gorge two miles away. The same thing was found in the Croton Valley, where at the New Croton Dam only three miles from the Hudson, bedrock occurs at Elevation 0, and in the valleys of Peekskill Creek and Sprout Brook, where, as disclosed by borings made by the Board, the bedrock lies in the neighborhood of Elevation 0 only three miles from the river. At New Hamburg, within about a half-mile of the river, bedrock in the old valley of Wappinger Creek was found at Elevation 40, all the way across.

Borings made along the southeastern half of the Moodna tunnel location, where the bedrock outcrops frequently, discovered two very deep and narrow buried gorges, one near Cornwall, and the other just at the foot of Storm King Mountain. The great depth of these two gorges was a surprize, as their presence is indicated on the surface only by shallow depressions, and without the borings they might easily have escaped notice.

SHAFT SITES.

At the northwest end of the siphon, where the vertical shaft for the waterway will be located, the drills show that a depth of about 120 ft. of glacial drift will have to be penetrated. This will require the construction of a reinforced structure above the rock after the manner of a stand pipe.

The great depth of glacial drift, over 350 ft. as a maximum, which fills the ancient gorge, would make it a very difficult matter to sink shafts for construction purposes in this long stretch of tunnel, but that the fortunate discovery of the ridge of bedrock between the two buried valleys mentioned, will make it possible to excavate a shaft at that point with only a moderate depth of soft ground to be penetrated.

Overthrust Faults.

The bedrock across this valley is mainly Hudson River shale and sandstone, with the bedding planes standing either vertically or at very high angles. At two points, however, the drills penetrated granit like that in the highlands to the south. Near Vailsgate, a narrow zone of granit was shown, with the shales on both sides of it. This occurrence was not entirely unexpected, as it lies almost directly in line with a great overthrust fault which runs for over 100 miles in a northeast and southwest direction. The same overthrust fault was explored by drills at New Hamburg, some ten miles to the north.

At the southeast end of the siphon, another great overthrust has forced up the granit of Storm King Mountain over the top of the shale. This fault is similar in character to that at the south end of the Rondout siphon, except that in this case a rock formerly beneath the shale now overlies it, while at the Rondout siphon the shale was forced up over a higher bed.

Near the edge of this great fault where the line crosses, there is a patch of limestone a few hundred feet in diameter, simply a remnant of a limestone deposit about 1 000 ft. thick which has been obliterated by the overthrust.

Material for Tunnel.

Drill holes and outcrops show the Hudson River shales to be rock well suited for tunneling. This material resembles the rock at the Wallkill Valley siphon. A short length of the tunnel will be in granit, which is in general very hard. Drill holes in the gully at the southeast end show it to be somewhat decomposed near the surface of the rock, but sound and unaltered in depth.

Borings.

On account of the great width of the Moodna Valley, and the unusual depth of glacial drift, more deep borings have been made on this siphon than on any other, unless it be the Rondout,

PLATE 23.
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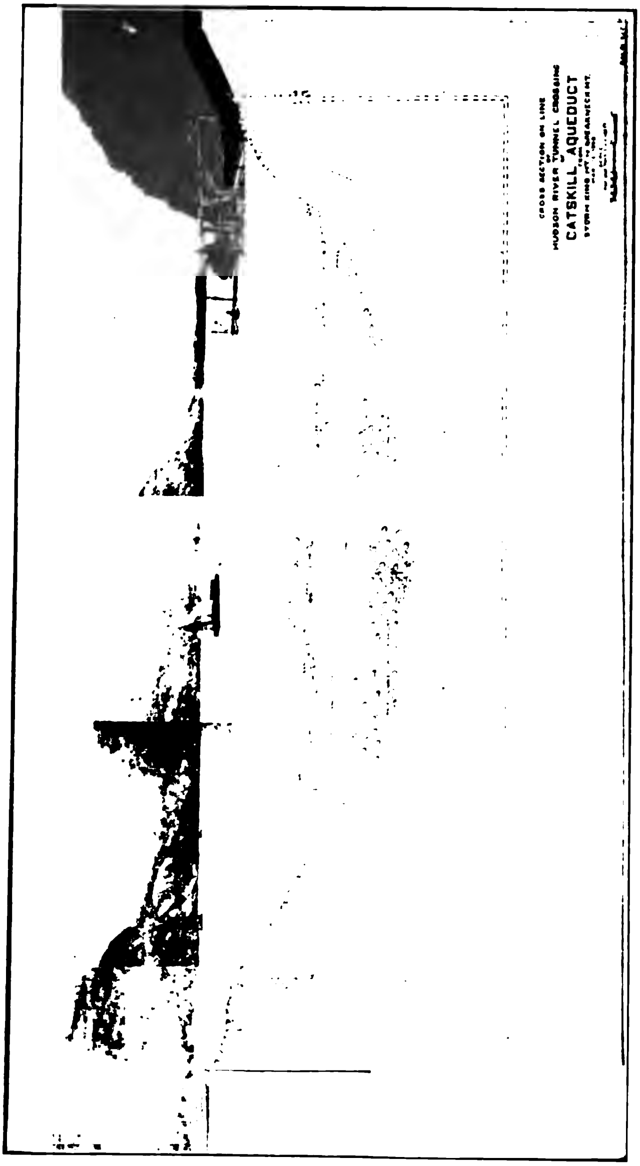
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Site of Proposed Rock Tunnel Under the Hudson River, Showing Storm King Mountain on the Right and Breakneck Mountain on the Left.

For drilling the hard clay and boulders, churn drills were first used, but the ground was so difficult that progress was very slow. The most rapid and satisfactory work in the deep surface material was made by using wash rigs and diamond drills, as at the Wallkill and Rondout siphons.

Shot and diamond drills were used where deep holes in rock were put down.

HUDSON RIVER SIPHON.

This siphon is the engineering feature of the department which has attracted more attention than any other and it would be hard to exaggerate its importance. As stated before, the problem cannot be eliminated as this tidal stream must be crost by the aqueduct whatever location is adopted. The hydraulic gradient at the crossing is over 400 ft. above the river surface, or nearly twice as high as the floor of the Poughkeepsie Bridge. A column of water of this hight represents a hydrostatic pressure of about 175 lb. per sq. in.

It is possible to carry the aqueduct across the river in a number of ways, among which may be mentioned.

1. A bridge 150 ft. or more above the water surface.
2. Several steel or iron pipes laid in trenches dredged in the river bottom.
3. One or more shield tunnels driven about 100 ft. below the river surface, steel lined or containing one or more steel or iron pipes.
4. A tunnel deep in the sound rock.

Of these the bridge is the most expensiv to construct and maintain and the rock tunnel is the cheapest. As the latter is also considered to be the safest and most durable, efforts have been made to find the most available location for it without eliminating the possibility of using some other form of construction if a thoro investigation should prove the rock tunnel to be impracticable.

In search of such a location every possible crossing has been considered and the river was studied in the field from Pegg's Point, three miles above New Hamburg, to Anthony's Nose in the Highlands, a distance of 21 miles. A narrow channel at the point of crossing was desirable and the geological conditions were an important factor, It is essential that the tunnel be in sound rock of such a watertight and durable character that no fear need be felt for its safety and permanence. It is needless to point out the disastrous effects of a break in the condit under the river and the impossibility of repairing it in a short time. Limestone is to be avoided if possible because of its uncertain character. At any of the upper crossings considered, this rock would have to be penetrated either in shaft or tunnel. At and below West Point in the Highlands, the presence of limestone of a more doutful character than that at the upper crossings was suspected with a greater depth of gorge. At Storm King and Little Stony Point granitic gneiss of an excellent quality is found on both shores with no indication of any change in its character under the river. This fortunate geological condition, taken in connection with the narrowness of the river at Storm King and with the better location leading to this point on both sides of the river, make for decided economy in the cost of construction by that route, and lead to the belief that this location is the best one, all things considered. For the past year or more, therefore, work has been concentrated at this crossing. (See Plates 23 and 24; Fig. 1.)

Before the grade of the tunnel below the river can be fixt, it is necessary to ascertain the depth of the ancient gorge. So far as the writer is informed, this gorge has never been explored from Albany to Sandy Hook, because heretofore there has been no occasion to do so. The piers of the Poughkeepsie Bridge rest on earth at a depth of 120 ft. below tide. Opposit Manhattan Iland a number of deep borings have been made for the proposed bridges and for the Pennsylvania and McAdoo tunnels, but as no necessity existed in connection with these projects for exploring the rock gorge, it was not done. The investigations of the Board of Water Supply are therefore in the nature of pioneer work, and the results will add much to the knowledge of the geology of the ancient stream.

The explorations are made by the following methods:

1. Wash borings;
2. Core borings;
3. Test shafts on the shores of the river, from chambers in which diamond drill holes are to be put out under the river.

Each method is described in some detail below:—

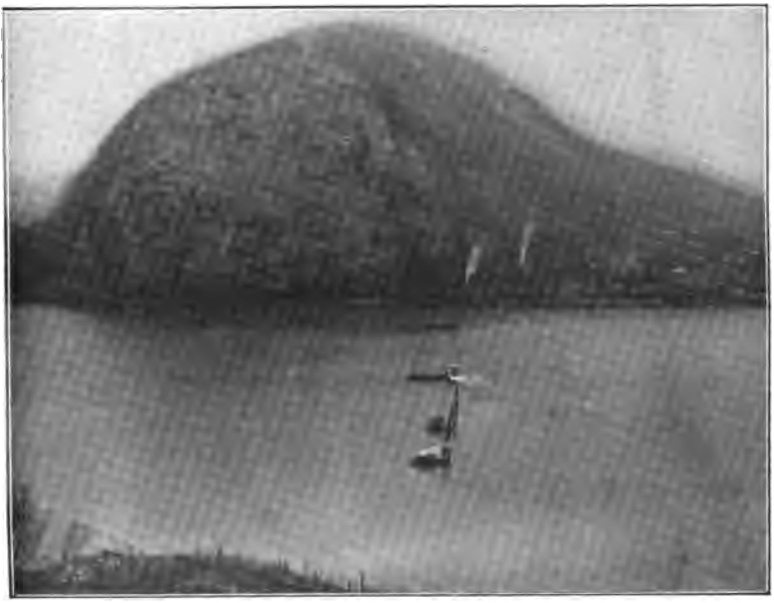


Fig. 1.—Boring Rigs on Line of Aqueduct Tunnel Under the Hudson River, Looking West Towards Storm King Mountain

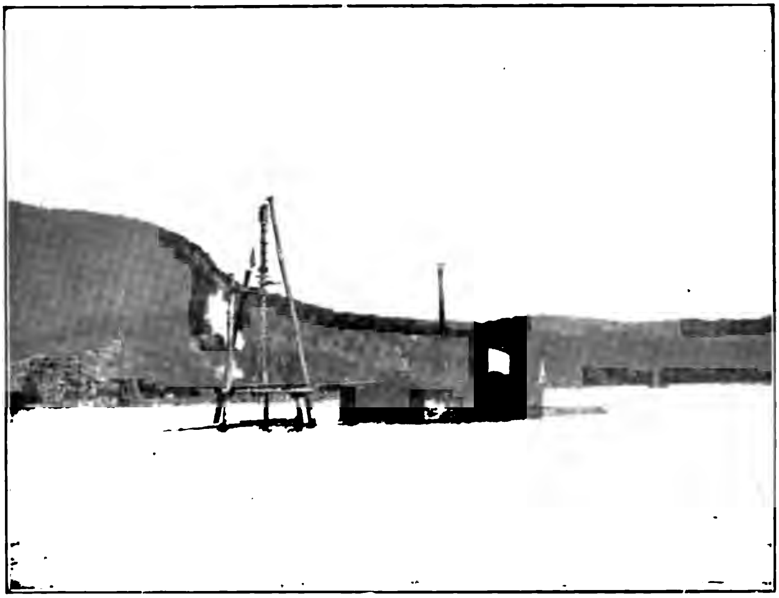


Fig. 2.—Boring Rig Mounted on Platform in Hudson River, on Little Stony Point Line.

WASH BORINGS.

At 14 cross sections of the river, lines of borings were made across the stream by means of wash drills, operated from the deck of a large lighter. The work was rapid and comparativly inexpensiv, but only negativ results were obtained, as the wash rods were stopt at depths between 100 and 300 ft. by boulders or hard material. As stated before, this method cannot be relied upon for positiv information in work of this character.

CORE BORINGS.

Core borings have been undertaken on only three cross-sections of the river, at Pegg's Point, the most promising one of the New Hamburg routes, at Storm King and at Little Stony Point, about 1¼ miles below Storm King. These borings are much more expensiv to make than the wash borings, and require far more time. The work in the river has been done under contract by the American Diamond Rock Drill Co., and their subcontractors, the Phœnix Construction & Supply Co. of New York.

At Pegg's Point three holes were successful in reaching ledge at depths of 92 ft., 241 ft. and 165 ft., respectivly, and the rock was penetrated far enough to recover good cores and ascertain its character. The river follows a fault at that point. One of the holes was east of it in limestone similar to that being quarried at Clinton Point on the east shore. Two holes were west of it in Hudson River shale. The deepest part of the gorge is probably on the fault line and was not explored, as by the time the borings mentioned were completed, it was decided for a number of reasons to investigate the Highland crossings. At Little Stony Point no boring was carried to rock. In September, 1906, the first core boring was begun on the Storm King line, and the work has been carried on there since, except during the winter months when the ice in the river prevents any work of the kind from being done. Of ten borings begun on this line only two have thus far been successful in getting down to the rock. Five were left unfinisht at the close of the last working season and three were lost thru the action of the elements. When the ice begins to form in the river the work is suspended for the winter and the casing pipes uncoupled below the navigation depth.

When the river opens in the spring the casings are connected up again and the work resumed. The positions of the holes are of course carefully located and the submerged pipes can be found without much difficulty. To carry on the work in the winter is out of the question, as the floating ice moving back and forth with the tide would carry away the scows and the casings and the holes would be lost. It is not safe to attempt to work from the ice when the river is frozen tight. Even if the ice became strong enough at any time to carry the weight of the apparatus, a sudden thaw would cause it to break up suddenly and result in the loss of the rigs and perhaps the men. All of the work therefore must be done from floating platforms. The methods are thus described by Mr. Walter T. McIntosh, the Assistant Engineer who acted as the inspector of the work last season:

"The equipment used on the river borings consisted of scows equipt with pile driving apparatus and duplex pumps of different makes and sizes. The outfit giving the best satisfaction was a scow 35 ft. by 100 ft., with 60-ft. pile ways, and equipt with a 40 h.p. Lambert hoisting engine, with Lambert boiler and Blake duplex pump delivering about 100 gal. per minute at 120 lb. pressure. The scows were held in place by means of from six to ten mushroom anchors, weighing in the neighborhood of 1 000 lb. each and having from 200 to 400 ft. of lead, according to the depth of water. Most of the anchor lines were ⅞-in. wire elevator cables, second hand, tho ½-in. iron chains and 2-in. manila lines were also used.

"The sizes of casing used were 14-in., 12-in., 10-in., 8-in., 6-in., and 4-in. casing and 2½-in. extra heavy drive pipe. Only two holes were started with 14-in. casing, the others being started with 8-in. or 10-in. The method of driving casing was to wash down with a 2-in. stream of water and drive the casing as close as possible after the wash pipe. It occasionally became necessary to bail out the casing, with a sand pump, when working in sand and gravel.

"When boulders were encountered it usually became necessary to blast them out of the way. Sixty per cent. dynamite was used in this work and shots consisted of from four to twenty sticks. When they were set off the casing was pulled back from 10 to 20 ft. At a depth of 473 ft., in one of the holes, a nest of boulders occurred which required six shots aggregating sixty-six sticks of powder to make it possible to drive the casing 2 ft. It was found, in general, that the first size of casing could be driven 100 ft. below the river bottom and each of the other sizes 100 ft. or more below the last preceding size.

PLATE 25.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.

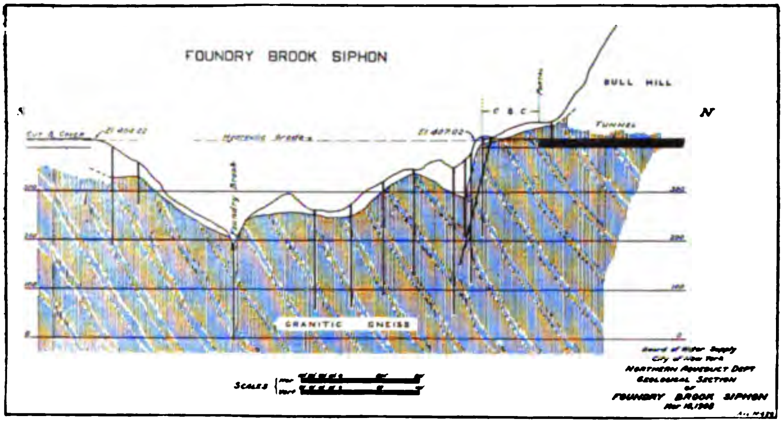


FIG. 1.—PROFILE ON LINE OF FOUNDRY BROOK SIPHON.

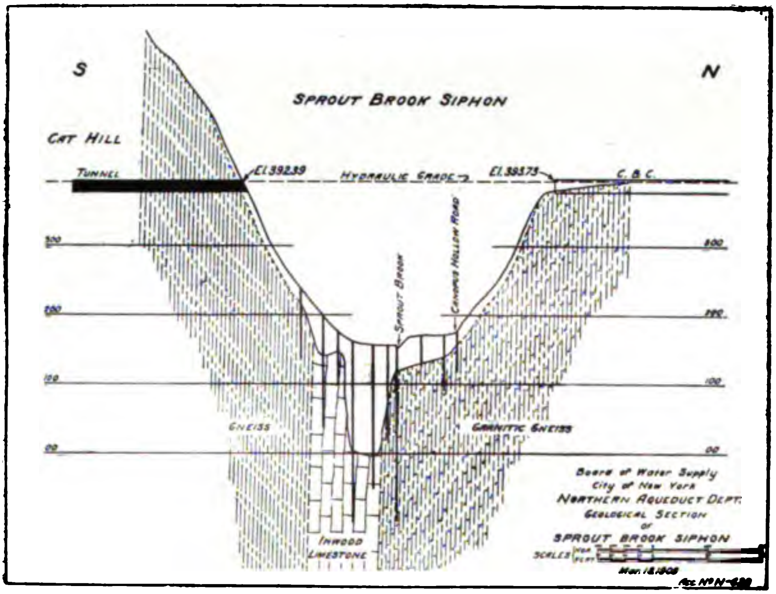


FIG. 2.—PROFILE ON LINE OF SPROUT BROOK SIPHON.

"When the casing brought up against something solid, that blasting would not remove, a platform was erected on the casing and the diamond drill set up. For this work an American Diamond Drill was employed, using 1⅝-in. rods and recovering 1⅛-in. core.

"The force on each barge consisted of a diamond setter and three or four helpers, depending on the size of casing handled. A superintendent on the ground had charge of all the work."

In the early stages of the work the platform for the diamond drill instead of being attacht to the casing, was supported by a tower formed of four piles driven into the river bottom. The bottom of the tower was about 25 ft. and the top 15 ft. square, the tops of the piles being drawn together and held by tie rods. It was found in practis, however, that the telescoped casing is stiff enough for the purpose, and the towers were given up as expensiv and cumbersome. Of the two borings at Storm King which have reacht rock, one, No. 16, 300 ft. from the east shore, encountered it at a depth of 201.4 ft. below the river surface, and the other, No. 10, nearly 800 ft. from the shore, at a depth of 608.6 ft. The latter hole was begun on September 10th, 1906. Operations on it were stopt for the winter in December, 1906, and were resumed in April, 1907. Altho work was prosecuted earnestly on it thereafter, it was not until the latter part of August of that year that the casing was seated in the rock and drilling begun. The diamond bit had gone 9 ft. into the rock and was making good progress, when, on the night of August 30th, the steamboat *Poughkeepsie,* having broken her propeller, drifted down against the casing, bending the latter and wrecking the platform. Investigation showed that the bends were below the river bottom and that straightening the casings was out of the question. The hole was therefore abandoned one year and a day after it was started. Altho only 9 ft. was bored into the rock, it is believed that the latter was ledge and not a boulder, especially as the core is of the same character as the rock on the mainland. This hole reacht the greatest depth attained thus far in the river work.

At the close of the past season one of the five unfinisht borings was down 580 ft., this depth having been reacht in 4½ months.

The work of making these river borings has been most difficult. It is not believed that such work has been attempted before under anything like the same conditions. Here the depths to be drilled are unknown and the problem is entirely different from one where a fixt grade only is to be reacht.

The channel at Storm King reaches a maximum depth of 85 ft., not far from the west shore. Underlying the channel is silt and clay, then sand and gravel of increasing coarseness, and boulders. Depths from 300 ft. to 400 ft. can be reacht with comparativ ease, and after the rock is reacht the drilling does not present very unusual difficulties. The troubles occur in the bed of gravel and boulders, where sometimes weeks are spent without the gain of a foot. Much trouble was experienced with the dynamite which often would not explode at great depths due to the pressure and the low temperature of the water. A failure to explode in such cases means much loss of time and generally of footage. Sometimes two lines of casing became bound together by gravel lodging between them, this preventing the smaller size being driven without carrying the larger with it. It should be remembered that every size of casing extends from several feet above the river surface to the depth to which it is driven. Serious troubles have also been caused by storms, the river in the contracted channel at Storm King being very rough at times. The anchors have dragged on a number of occasions, and this has resulted in the loss of three holes on that line.

A number of diamond drill holes have been drilled on the shores of the river in connection with the investigation of the crossings, but it is not considered necessary to describe them here.

TEST SHAFTS.

As it is not practicable to make enough core borings in the river to locate a possible fault or a narrow crevice in the bottom of the gorge, and as the encountering of a waterbearing seam by the tunnel at such a depth might mean the loss of the heading, it was decided to sink two shafts, one on each shore, to a depth of 650 ft. below tide, and from chambers excavated in their sides put out horizontal or inclined diamond drill holes that would cross under the middle of the river and furnish evidence of the character of the rock all the way across. As the shafts are to form part of the permanent construction, they were located and designed accordingly. Work was begun on them early in 1907, under agreement with the Cranford

PLATE 26.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.

Boring Rigs on Line of Sprout Brook Siphon.

Company of Brooklyn, and to date each has been sunk approximately 250 ft. At elevation —185 headings were turned for the aqueduct on the land sides and were driven about 25 ft. so that they can conveniently be extended later. Below this elevation the shafts are circular in section, as they are to form the aqueduct waterway.

Excellent rock has been encountered all the way down of the same general character as the outcrops. The shafts have been remarkably dry. About 5 gal. of water per minute only has to be removed from the east shaft, and is easily taken care of by bailing. In the west shaft the quantity to be handled is about 12 gal. per minute, but sometimes reaches 18 gal. after a storm, most of it coming from the surface.

FOUNDRY BROOK SIPHON.

The aqueduct line crosses the valley of Foundry Brook near Cold Spring, with a length of ¾ mile below hydraulic grade. Explorations of the bedrock were made with core drills, to determin its suitability for a siphon tunnel. (See Plate 25, Fig. 1.)

The rock is hard granit and gneiss, everywhere of good quality except near the north end, where several of the drill holes showed the rock to be so badly disintegrated in the lower part that it would not give a core. This bad ground is about 300 ft. wide, with holes on either side in sound rock. Water flowed from two of the holes, in one case under strong pressure.

It was thought that the drill holes, apparently in bad ground, might have followed down in soft, narrow seams, where the rock had become disintegrated on vertical joint planes, so an inclined diamond drill hole was bored, to cut at a rather flat angle across the bad ground. This hole penetrated the doutful zone, and proved that the material was pretty thoroly disintegrated. In fact, the rock failed to core, and was so soft that it fell in around the drill rods, wedging them so that they were twisted off, and the diamond bit lost. A considerable time was spent fishing for the bit, but it was never recovered, on account of the caving in of the hole.

The idea of bilding a tunnel across this rather narrow valley was abandoned, and a pipe line adopted, as it was considered unwise under the circumstances to attempt a tunnel, altho the difficulties of driving thru the bad rock were not considered by any means insurmountable.

In this valley no deep drift-filled gorge in the bedrock was encountered.

SPROUT BROOK SIPHON.

This valley is only ½ mile wide, with granit on both hillsides at hydraulic grade. (See Plate 25, Fig. 2.)

Both above and below the proposed crossing, limestone appears in the bottom of the valley, but at the crossing there is a deep deposit of glacial drift.

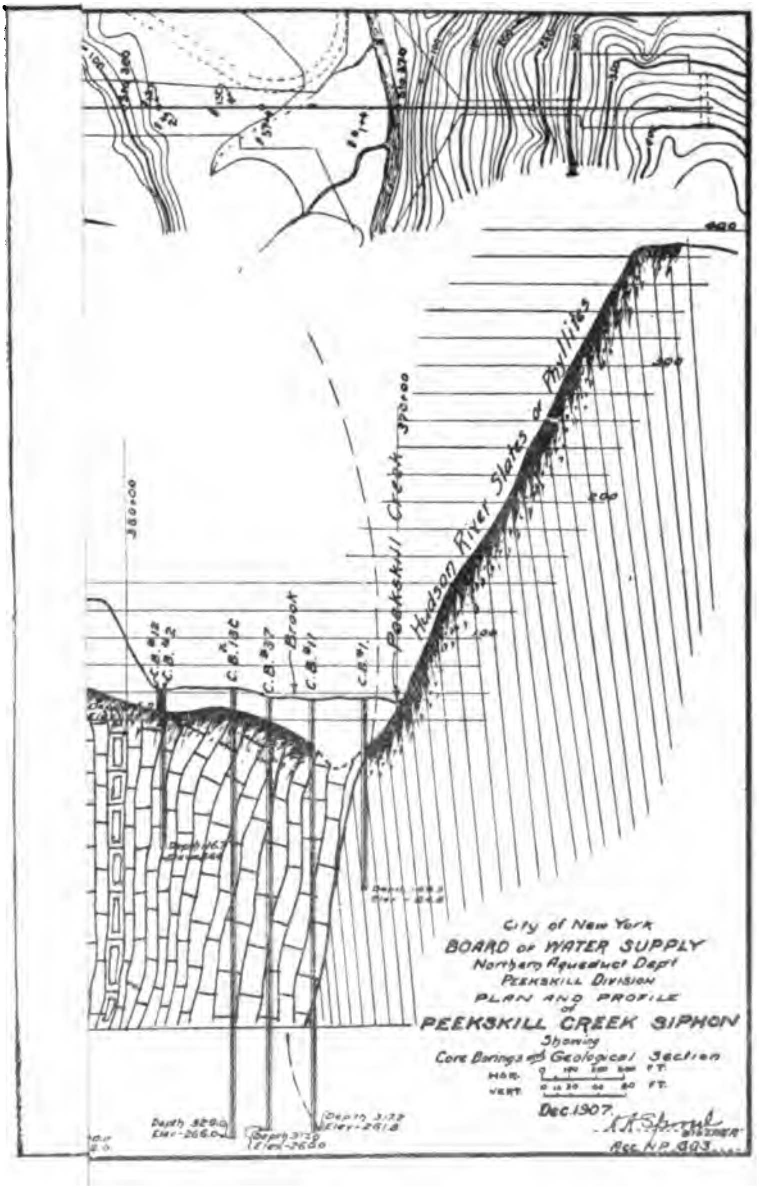
Borings were put down to discover the bedrock profile (see Plate 25, Fig. 2), and disclosed a V-shaped valley in the limestone, filled 150 ft. deep with gravel and sand. This rock is a crystalline marble, similar to that penetrated by the New Croton Aqueduct tunnel under the Harlem River. That tunnel, as is well known, was originally to have been driven at a depth of 150 ft. below the water surface. At a distance about 300 ft. from the shaft on the Manhattan side, the heading encountered a seam of disintegrated rock on the contact line between the gneiss and limestone, which admitted water in such large quantities to the tunnel that it was decided to abandon the heading already driven. After the seam was explored by means of diamond drill holes bored from a chamber excavated in the tunnel, a new grade for the latter was fixt about 150 ft. deeper, and when so constructed the new heading was perfectly dry.

The character of the rock at Sprout Brook would make it necessary to go much deeper below the buried gorge than would be required in sounder rock, so that the two shafts for a siphon tunnel would have to be sunk 600 ft., and the actual length of the condit would be increast 50 per cent. On this account, it was considered cheaper to use steel pipes.

PEEKSKILL CREEK SIPHON.

The length of the aqueduct below hydraulic grade in the Peekskill Creek valley is about 1½ miles. As in the case of the other valleys crost, core borings were put down to develop the bedrock profile, and to show the character of the rock. In the comparativly small width of the valley, four rock formations were discovered,

PLATE 27.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
RIDGWAY ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



consisting in their order from north to south of (1) Hudson River shale, (2) Wappinger limestone, (3) Georgia quartzite, (4) Fordham gneiss. Of these the first is the highest geological formation, and the last named the lowest. (See Plate 27.)

All these formations have been very violently disturbed, and are extensivly folded, faulted, and metamorphosed, and the strata stand very nearly vertical.

The borings were in most cases put down very deep in the rock to elevation —250, especially in the limestone belt, where the tunnel grade was expected to lie deepest. It was shown that most of the rock was apparently sound enough for a tunnel, but several of the limestone holes failed to secure cores. In one case, a diamond bit was lost in a crevice filled with sand, and was recovered only after many trials.

The bedrock profile, which is buried a hundred feet deep by a glacial sand plain, was shown to be unexpectedly flat and regular, with no deep-cut V-shaped gorge, contrary to the predictions of the geologists.

It was thought that considerable leakage thru the rocks might take place due to their deep weathering. Experiments with oil-well pumps were undertaken in several of the drill holes, and showed that, in the weak zones, the rock was in a disintegrated and sugary condition, not unusual in weathered limestones.

On account of the great depth of shafts, and the doutful character of the limestone, it was decided that a steel-pipe line on the surface will be more economical than a rock tunnel.

In conclusion the writer desires to record his indetedness to the engineers of the Northern Aqueduct Department who have assisted him in writing this paper, particularly to Assistant Engineer James F. Sanborn, who has prepared for him the detailed descriptions of most of the siphons.

SOUTHERN AQUEDUCT DEPARTMENT.

BY MR. WILSON FITCH SMITH. *

The Southern Aqueduct Department of the Board of Water Supply was organized in the Spring of 1906, and the subsurface investigations described below were carried on in connection with the surveys during the remainder of 1906 and 1907.

KENSICO DAM SITE.

For the purpose of making a storage reservoir of considerable capacity on the line of the Catskill Aqueduct in the vicinity of New York City, it is proposed to bild a dam across the Bronx River valley at Valhalla. The site selected is near the present Kensico Dam, which impounds the runoff from the watershed of 22 sq. miles, tributary to the Bronx and Byram Rivers, forming what is known as Lake Kensico.

The proposed dam will be a masonry structure of the gravity type, with a spillway at elevation 355. This will form a reservoir of about 2 250 acres with a total capacity of about 40 000 mil. gal. and an available capacity of about 20 000 mil. gal.

The total length on the crest, 15 ft. above the spillway elevation, will be about 2 300 ft., 1 100 ft. of which will have a hight greater than 150 ft. The hight of the maximum section will be over 250 ft.

The location of this dam is fixt within very narrow limits by the configuration of the ground. The most favorable location is about 400 ft. above the present dam; the chief objection to this site was its interference with the present reservoir. The next best site, and the one explored in detail, is about 400 ft. below the present dam; the chief objection to this site is the interference of the present reservoir with it, on account of the danger of disturbing the present dam, which is of earth with a masonry core-wall founded on rock for part of its length only.

The Bronx valley at this point lies between two parallel ridges, which rise somewhat abruptly to a hight of 170 ft. to 180 ft. above the bed of the stream. The westerly ridge terminates suddenly just

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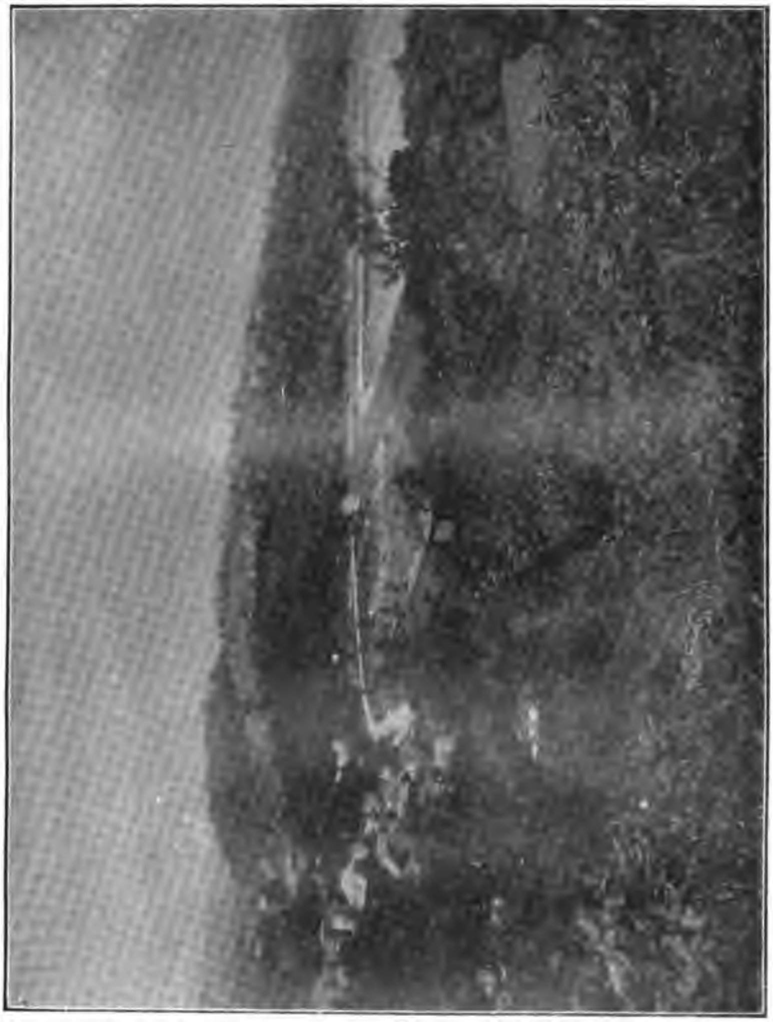
* Division Engineer, Southern Aqueduct Department, Board of Water Supply.

PLATE 28.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SMITH ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



KENSICO RESERVOIR, LOWER DAM SITE FROM EASTERLY END. VIEW POINT ON THE UP-STREAM FACE AT THE FLOW LINE. LINE PASSES THRU THE SQUARE BILDING IN THE FOREGROUND.

below the lower site. The westerly ridge is composed of mica schist, while the easterly ridge is of gneiss, both outcropping sufficiently to give the direction of the strike and dip. These are generally the same for both ridges, the azimuth of the strike being about 13° and the dip about 55° to the west. Between the ridges there are no rock indications, the material of the valley being drift of a generally porous nature.

The first step in the survey was to make a topographic map of the vicinity by stadia methods on a scale of 1 in. = 40 ft., with contour intervals of 2 ft.

Preliminary explorations by wash borings on the site below the present dam indicated the bedrock to be approximately at elevation 180 all across the valley. The site above the present dam was then explored by a line of wash borings, those in the lake being made from a raft. These indicated the general level of the bedrock to be about the same elevation as below the dam, except near the east side of the lake, where a gorge was developt which went as low as elevation 130. The material filling this gorge was sand containing a considerable amount of limestone. The inference was at once made that this gorge must continue to the lower site, and efforts were made to locate it by wash borings. These gave quite consistent results, verifying the previous borings, and led to considerable speculation over the lost gorge. As soon as core-drilling machines could be gotten on the ground, a systematic and thoro investigation of the lower site was started. First a single line with holes 200 ft. apart was explored; this developt the structure of the valley. Later the intervening spaces were filled in with holes 100 ft., 50 ft. and in some places 25 ft. apart, also on parallel lines 100 ft. apart at corresponding stations, so that cross-sections at right angles to the axis of the dam could be constructed; altogether 63 holes on 7 lines were put down.

The first line of holes developt a stratum of crystalline limestone in the valley about 400 ft. thick separating the schist and the gneiss, and on the contact between the limestone and the gneiss was found the gorge, substantially of the same depth and width as found at the upper site. A heavy layer of boulders in the overlying till had prevented the wash-boring drills from penetrating to the gorge, even tho the holes were shot two and three times, again proving the purely negativ evidence afforded by wash drills.

The geological section of the valley thus developt is similar to that of the Peekskill Creek, except that the dip is in the opposit direction and the rocks are more crystalline. The limestone in places is deeply decayed, especially along the contact with the gneiss, and the decay includes the gneiss in the vicinity of the contact. This extends to a depth of more than 50 ft. in the gorge. The schist shows less depth of decay, but is in places badly shattered, and shows generally crusht zones or lines of weakness following the bedding planes.

The area has been carefully studied by Dr. Charles P. Berkey of Columbia University, and Prof. W. O. Crosby of the Massachusetts Institute of Technology, whose deductions throw some interesting light upon the formation, which may be summed up as follows:

The valley is an eroded limb of a simple geological fold.

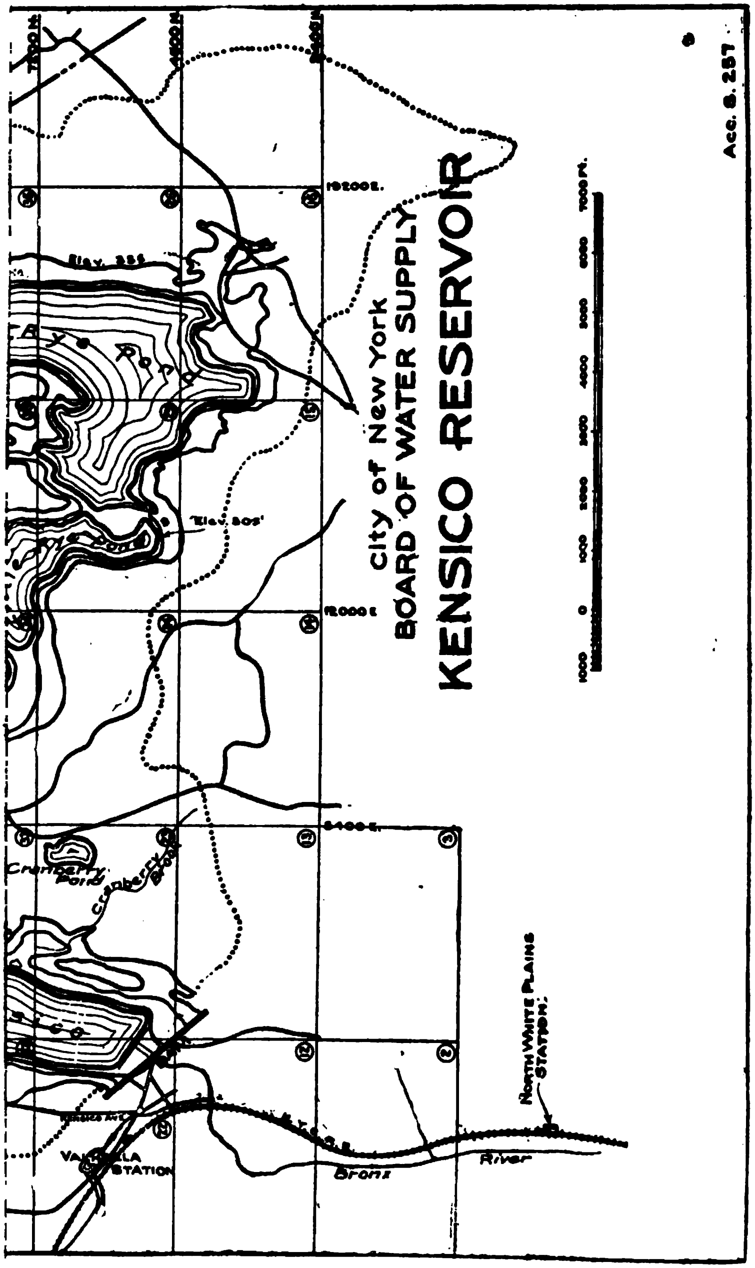
The gneiss is of the Fordham formation; the limestone is highly crystalline, some of it quite pure, and is similar to that found in many of the valleys of lower Westchester County, reaching its greatest purity in the Tuckahoe Quarries. The schist is similar to the Manhattan schist.

The base-leveled rock floor was formed by erosion before the continental uplift preceding the glacial period, and the principles of physiography demand an eroded gorge which should have been formed during the uplift. That the borings failed to find this gorge indicates that it is either of narrow limits, and therefore will probably not greatly influence the design of the dam, or else it was never very deep and was effaced by glacial erosion.

The gorge at the contact of the limestone and the schist is the result of preglacial disintegration, and that this was not washt out during the glacial period is due to its being protected from the glacial movement by a prominent ridge just east of it.

Besides the explorations made at this dam site, borings were made at the dike site about a mile above the dam on the west side of the basin. The divide is some 14 ft. below the proposed flow line, the hills being broad with flat slopes. Here the drift was found to be very heavy, impervious boulder till of the nature of hardpan, baffling absolutely the wash boring apparatus. Schist rock was found at a maximum depth of 155 ft.

PLATE 29.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SMITH ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



All of these holes were vertical and were made with shot drills of various sizes and types. As many as 8 drills were at work at one time. The most effectiv was a local type of the Beal pattern, combined with a small jar drill similar to those seen in the oil region, the jar drill being used to sink the casing.

Several holes at an angle of 30° with the horizontal were made with a diamond drill, for the purpose of exploring quarry sites.

The approximate cost of the shot drill holes, including labor supplies and a percentage of the total cost of the plant for depreciation and repairs, ran from $1.14 to $6.52 per foot, with an average of $2.40 per foot. The average cost of the diamond drill holes on the same basis was $3.62 per foot. The total length drilled was 4 933 lin. ft. The depth drilled per day workt varied considerably with the different machines, due to the nature of the ground and manipulation, the average for all machines was 5 ft.

The size of the cores varied from 1⅛ in.. to 5 in. in diameter, the larger holes being more satisfactory as they yielded a greater per cent of core.

The wash borings on land cost the contractor $0.41 at the dam site, and $0.80 at the dike; water borings, including an average depth of 20 ft. of water, $0.22 per foot.

CROTON LAKE CROSSING.

The crossing for the aqueduct under Croton Lake was located where the most favorable surface conditions appeared. It is about ½ mile below the Old Croton Dam, at one of the narrowest parts of the valley, being 1 350 ft. wide at high water line. The sloping banks on each side reveal outcrops of mica schist. A shot drill hole of 6 in. diameter was put down on each bank and four diamond drill holes 1⅝ in. diameter were sunk in the lake, spaced about 250 ft. apart. The deepest of these was 377 ft. They revealed a maximum depth of 200 ft. to the base level overlaid with about 135 ft. of drift. The crossing is entirely in the Manhattan schist formation, showing two varieties, coarse grained metamorphic quartz-mica, garnet-bearing rock and a finer grained hornblende rock.

The cores developt occasional crusht zones but the general quality of the rock improves with depth, indicating a favorable location for the tunnel between elevations —110 and —150.

The crossing is located at one of the points where the Croton River crosses the normal geological formation at right angles to the general direction of the folds. It is probably underlaid by the limestone, the next older of the series of this region, but this was not reacht by the deepest hole.

The existence of crusht zones led to the consideration of the possibility of leakage thru the joints or planes of fracture. The cores show that these are filled with chlorite, a secondary mineral of little strength, but under examination showing but little decay.

An attempt was made to test the shore holes by bailing or pumping them out. A 4-in. pipe with a ball valve at the bottom was inserted to the full depth of the hole, and a rod carrying a piston and valve at the bottom was inserted in this pipe. By raising and lowering this plunger the hole was drained. The maximum flow obtained was about 50 gal. per minute.

At the depth the tunnel will be located it is expected that but little difficulty will be experienced from water.

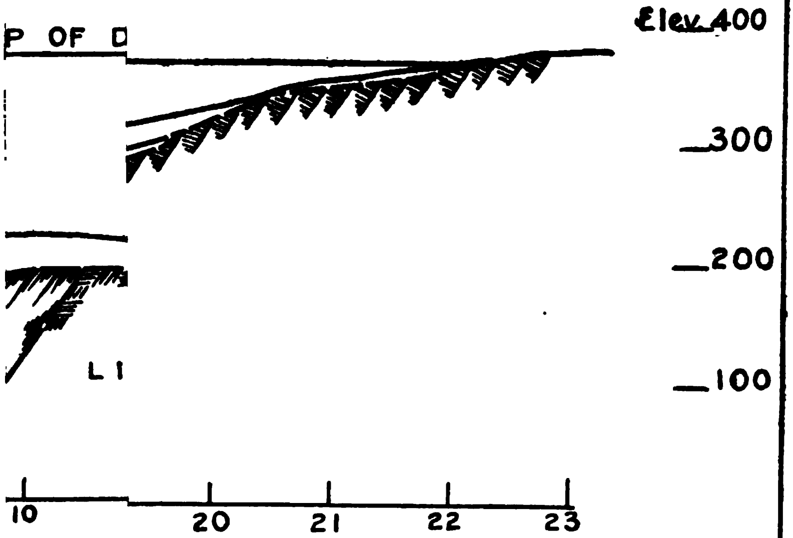
No data as to the cost of this work are as yet available, the borings having been but recently finisht.

GENERAL.

Explorations by wash borings and test pits have been made of five filter sites, numerous sand areas and all of the tunnel portals and siphons in the department.

Core borings are in progress at the siphon sites where there is any uncertainty of the results shown by the wash borings. Rod soundings have been made along the cut and cover portions of the aqueduct; these cost less than half as much as wash borings, are much more rapid and, in shallow ground, give nearly as satisfactory results in the location of bedrock.

PLATE 30.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SMITH ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



City of New York
BOARD OF WATER SUPPLY
KENSICO RESERVOIR
CROSS SECTION ON "E" LINE
Nov. 22, 1907.

Acc. S. K. 776

LONG ILAND DEPARTMENT.

By Mr. Walter E. Spear. *

The investigations for a ground water supply from Suffolk County have comprized extensiv topographical surveys, stream gaging, test boring and many studies of problems of interference with local interests that might, in the future, arise thru the proposed diversion of the Suffolk County ground waters.

All these investigations have necessarily been directed toward the sources of the proposed supply below the ground surface; but it is here intended to describe only the test boring which has been carried on to learn the extent of the ground-water sources and the best means for their development. There is hardly time to discuss the results of this work, and it is not possible now to give the conclusions of the investigations.

SURVEY OF THE SURFACE OF SATURATION.

The first work in Suffolk County, which was begun in November, 1906, shortly after the organization of the Long Iland Department, was the driving of 2-in. test wells to determin the configuration of the main water-table, or the upper surface of the saturated sands and gravels.

The substrata in Suffolk County, to a depth of 600 to 1 200 ft. or more, is made up of unconsolidated sands and gravels, interbedded with irregular lenticular masses of clay. The clay strata are not continuous, and the ground water penetrates to great depths in the pervious sands and gravels. Excepting on the morainal ridges and a portion of the north shore that has been greatly disturbed by movements of the ice sheet during the glacial epoch, the surface soils and substrata of Long Iland are generally pervious, and a large percentage of the rains that fall upon the surface of the iland sinks quickly thru the open, sandy soils to the deep strata below. The ground water thus formed moves away in a northerly or southerly direction from a summit approximately in the center of

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* Division Engineer, Long Iland Department, Board of Water Supply.

the iland, and escapes into the sea after many months and years in the ground.

This summit of the main water-table, or the surface of saturation, does not coincide with the surface divide along the irregular crest of the hills that form the backbone of the iland, and it was necessary to make a survey of the entire water-table in order to determin the area of the ground-water catchment that would be tributary to the proposed collecting works in southern Suffolk County.

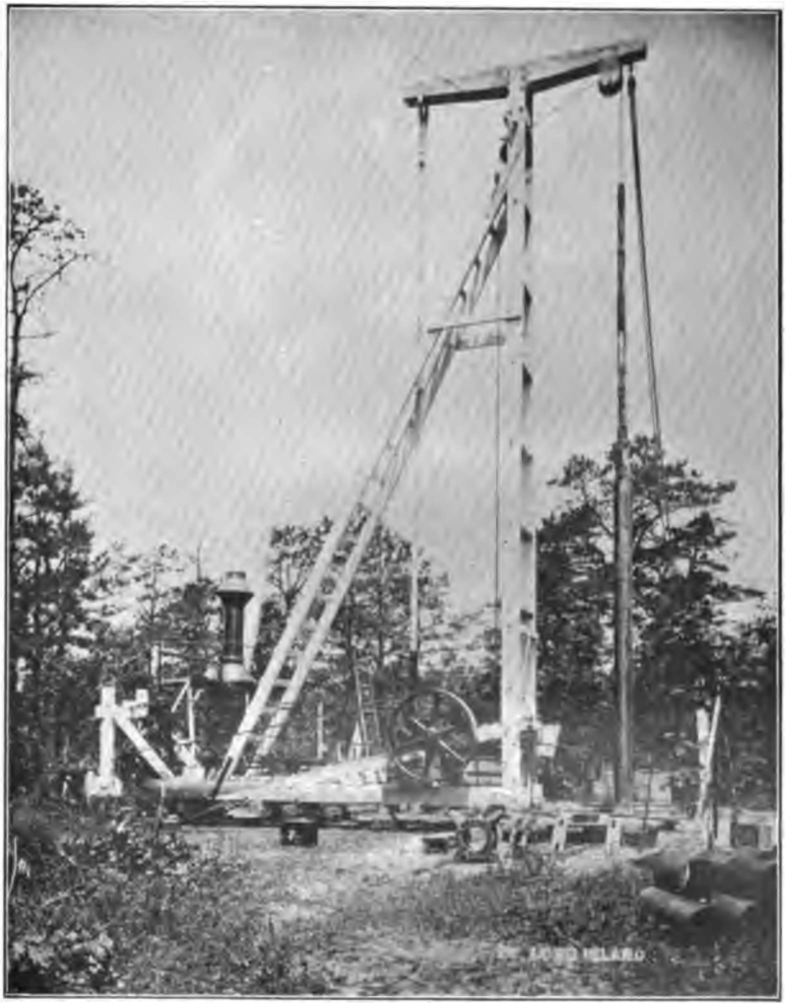
For this purpose 504 2-in. test wells, aggregating about 21 600 lin. ft. of pipe, were driven by wash-boring methods into the saturated sands, and left in place for observations of the ground-water level. A few test wells had been previously driven by the Brooklyn Water Department in the vicinity of Amityville, and many were put down in 1903 by the Burr-Hering-Freeman Commission. Numerous private dug and driven wells were also available for observation, so that the ground-water surface could be surveyed in many districts without driving any additional test wells. Most of the wells driven by the Board of Water Supply were in the southerly half of the county, from the Nassau County line to Quogue, and in northeastern Suffolk County between Port Jefferson and Riverhead.

All wells were leveled upon during the past year, ground-water hights were observed, and a contour map of the surface of the saturated sands and gravels made up similar to that prepared under the direction of the writer by the Burr-Hering-Freeman Commission in 1903. From this ground-water map the Suffolk County catchment areas were workt up, just as the surface drainage of a watershed is determined from a topographical map.

DEEP BORINGS.

Altho samples were taken in most of these 2-in. test wells, it was appreciated that an accurate knowledge of the coarser water-bearing strata could not be obtained by small wash borings. Furthermore, most of the 2-in. test wells were only 30 to 40 ft. in depth; and were driven solely for the purpose of surveying the surface of saturation.

To investigate the water-bearing gravels and learn something of the deep strata beyond the reach of the ordinary methods of boring, the Board of Water Supply purchased and assembled at Babylon,



California Drilling Rig at Test Well No. 2, West Islip, Long Island, July 22, 1907.

L. I., in the winter of 1906-1907, a large rig for sinking the California stove-pipe well.

The stove-pipe well and the peculiar rig for driving it adopted in southern California was first designed to meet the conditions existing in and about Los Angeles, where ancient valleys have been filled to great depths with beds of sand, gravel, clay and large boulders.

According to the testimony of the drillers in Los Angeles, the standard oil rig and casing designed for drilling in the consolidated formations of Pennsylvania, which were brought to the coast when oil was first found there, proved a failure and were given up for the stove-pipe well that is to be described.

The stove-pipe well, when in place, is a double casing made up of joints 2 ft. in length, from which the name "stove-pipe" comes. Each joint is a round cylinder of uniform diameter made of hard red steel and single riveted longitudinally with about 16 soft iron rivets. The ends of the joints are made square and smooth and butt against each other. The inner and outer tubes fit together tightly, and the butt joints of the inner line are in the center of the units that make up the outer casing, and *vice versa*. This gives the casing much strength and flexibility, and the construction permits the well to be rapidly assembled in the field. The first 17 to 21 ft. of the well is made up in advance, well riveted together and fitted with a forged steel cutting shoe at the bottom. This rigid starter is essential in order that the well will go vertically when being driven.

A distinct advance was made in the stove-pipe casing during the past year by the Board of Water Supply. A lot of electrically welded casing was made up by a firm in Pennsylvania that proved better in every way than the riveted casing. The welding is all done mechanically and gives more uniform fits and a much stronger casing than the riveted material. The welded casing also makes a tight well, which is a great advantage in oil-well practis and in water-supply work.

The casing is forced into the ground by means of one or two pairs of hydraulic jacks set up about the well and attacht to a plank and timber platform buried at a depth of about 10 ft. The jacks are specially made for the work and have large links that fit over lugs on the drive-head that sets on the top of the casing. The material is removed from within the casing as it advances, by a large sand bucket, or "mud scow" as it is sometimes called, which is operated from a walking-beam rig peculiar to California and the Southwest.

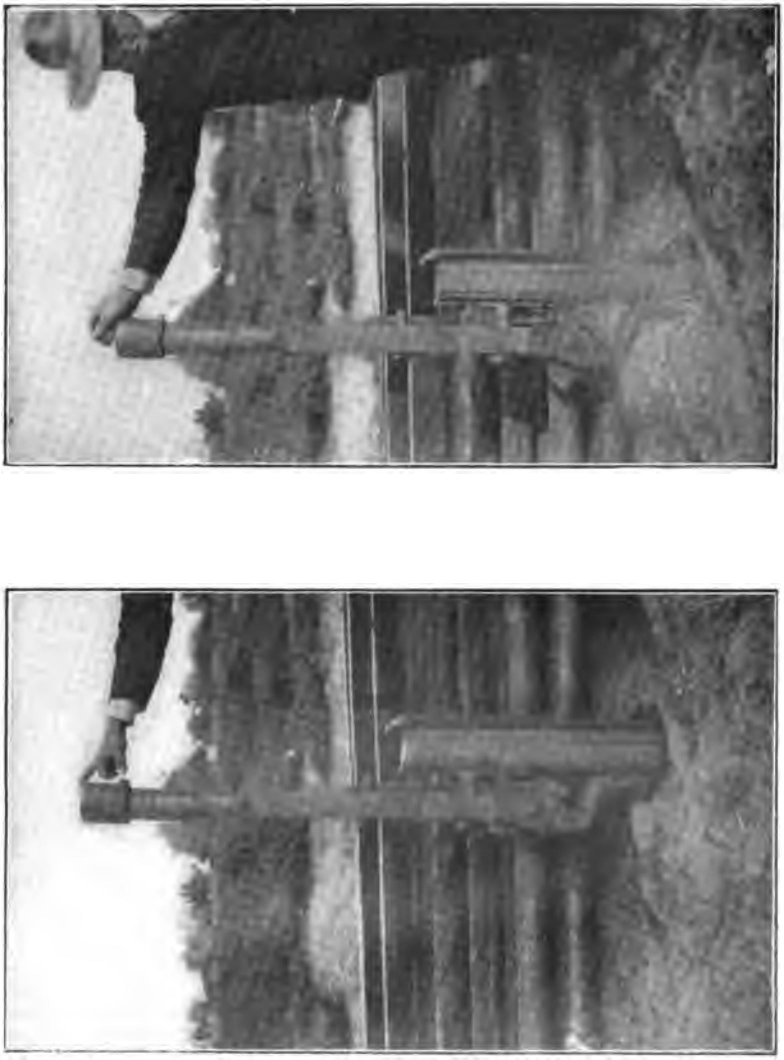
The rig used in California for deep work is 50 ft. in hight. Plate 32 shows the rig constructed by the Board of Water Supply, which is only 36 ft. high. This rig, like that in California, has at the top of the gins a heavy walking-beam by which the sand bucket, attacht thru standard link jars to a cable passing to the drum of the machine, is churned up and down by the motion given the walking-beam by the pitman and the crank on the operating gears below. By adjusting the length of the crank, a stroke of 14 to 20 in. is given the bucket, according to the character of the material encountered. The walking-beam gives the bucket a sharp, free drop that seems to be necessary for the proper operation of the bucket.

The sand bucket itself differs in nothing except in size and weight from those ordinarily used in the East. It weighs about 1 200 lbs. and is equally effectiv in breaking up and removing boulders and in taking out loose sand and clay. As the well descends and the bucket fills, it can be lowered by means of the friction feed operated by the lever at the front of the machine. This is much less delicate than the screw feed of a standard rig, but permits of rapid work in loose, unconsolidated formations.

The rig is seen to be compact, the pump, engin, and sometimes the boiler being carried on the bed of the machine; the ladder may be removed and the gins folded back when moving the rig. Three men are ordinarily required for its operation: the foreman, who stands at the front of the machine where the pressure pump, the engin, the clutches and the friction feed are operated; a helper to handle the sand bucket when it is emptied, and a fireman who tends the boiler and looks after the engin. Much skill is required by the foreman operating one of these rigs, which is only to be gained by long experience. The foreman, who always holds his hand on the cable when drilling, must know when the bucket is digging, when it is full, and how far the bottom of the bucket is below the casing, in order not to come to grief.

In driving a well, the anchorage pit is first dug, the platform and jacks set in place and the first section of the well, the starter, is set up vertically in the center. The rig has already been erected to facilitate the placing of the jacks and starter, and the driving is

PLATE 33.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SPEAR ON SUBSURFACE
INVESTIGATIONS OF THE
BOARD OF WATER SUPPLY.



Knife Perforator for 16-Inch Stove-Pipe Wells.

Fig. 1.—Knife Closed Ready to Lower into Casing.

Fig. 2.—Knife Open Ready to Perforate Casing.

begun. Some difficulty is generally met, when the upper strata are coarse, in getting the starter down. The sand bucket will only work to advantage when it is covered by sufficient water to give the necessary circulation thru the valve. It is essential, therefore, to keep the starter full of water, which is not always easy to do when it is some distance above the water-table in coarse sand and gravel.

After the starter has been pusht down to the level of the top of the jacks, the drive-head is attacht to the top of the bucket and lifted from the casing. One inner and one outer joint of the casing are placed one after the other, and seated by means of the jacks. When these two joints are in place, the outer shell is lockt to the inner one by denting the casing with a sharp pick, and when the whole casing is driven approximately 2 ft., another pair of joints are seated and the work procedes. In this way the well is driven as far as desired. Large wells in southern California have been driven to depths of 1 200 ft. with a single line of casing.

Stove-pipe wells, from 12 to 16 in. in diameter, have been driven on Long Iland. For these sizes, sand buckets with a 10 and 12 in. barrel have been used. The valves of these buckets are tight, and the material is brought up from the bottom just as it lies, without the separation of the coarse and the fine that occurs in wash boring. The very best knowledge of the water-bearing strata is therefore gained, and any stratum that promises well can be drawn upon.

Two types of perforators are used to admit the water to the well: one a knife perforator (see Plate 33, Figs. 1 and 2), which is operated with the hydraulic jacks on a line of 3-in. extra heavy pipe, and which makes slits 8 in. to 1 ft. in length, and ⅝ to 1 in. in width; another, known as the "Star" perforator, is used where the material is not sufficiently coarse to permit the use of the larger knife. This is similarly operated, and makes a line of small slits, 3 in. in length and ⅛ to ¼ in. in width wherever desired. The knives of both perforators are thrown in or out by means of a trip line of ¾-in. pipe operated by block and tackle at the surface. Four of the larger perforations can be made in one diameter, altho it is customary to stagger them somewhat to avoid spreading the pipe. The smaller slits can be made about 3 or 4 in. apart in the diameter of the casing.

After the perforations are made, it is customary to remove the larger gravel that has come in thru the perforations, by means of the sand bucket, after which the well is pumpt deeply to remove the fine sand that may be in the gravel about the casing, and thus complete the natural filter around the pipe. It is possible to perforate the casing where there is only a very small percentage of gravel, sometimes not much over 2 or 3 per cent. of the whole mass. When coarse material does not exist in the upper 30 or 40 ft., gravel can sometimes be dumpt around the casing at the top and allowed to find its way down to the perforations as the sand is pumpt out.

Eight wells, aggregating about 3 800 ft. of casing, have been driven in Suffolk County. One well, 14 in. in diameter, near Babylon, penetrated to a depth of 812 ft., and another, 12 in. in diameter, in the vicinity of Brookhaven, on which we are now working, has been driven to a depth of something over 900 ft., with one line of casing. An average progress of 30 ft. a day has been attained on this well, including time lost on repairs to rig and pump.

The cost of the casing delivered on the ground in Suffolk County has averaged about $2.25 per foot of completed well, ranging according to size, from $1.50 to $2.50. The driving of the wells has cost about $4 a foot, including the cost of moving and setting up the rig. The cost of moving has been large, and much of the work has been deep. Wells of moderate depth should be driven for $2.50 to $3 per foot if they are within easy moving distance of each other. You will see that the total cost of these wells will range from $5 to $6 per foot, which is comparativly cheap for their size and depth.

It is not unusual, in southern California, to obtain from one to three million gallons or more per day from each well. The pumping experiments that we have made near Babylon showed that a 16-in. well readily yielded 1 250 000 gals. per day, with only a moderate lowering of the ground-water surface. By pumping deeper, 2 million gals. per day were obtained for a short time.

The stove-pipe well has been proven to be admirably suited to the conditions existing on Long Iland. It is comparativly inexpensiv, provides large yields, and should come into general use in the east, where unconsolidated strata of sand and gravel exist. Much interest has been displayed in stove-pipe wells by engineers and contractors in this vicinity, and I anticipate that this method of sinking casing will come into use for many purposes.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 40.

PRESENTED APRIL 22, 1908.

THE POSSIBILITIES OF THE ESTHETIC DEVELOPMENT OF OUR CITY.

BY MR. CHARLES ROLLINSON LAMB.*

WITH DISCUSSION BY
ROBERT RIDGWAY, ARTHUR S. TUTTLE, GEORGE W. TILLSON,
ALFRED D. FLINN, WALTER G. ELIOT, ALBERTO SCHIRMER,
AND THE AUTHOR.

Those of us living in the Boro of Manhattan in the old days, who wisht to emphasize and develop the civic spirit, urged as a possibility, not so many years ago, the Greater New York, and this, our field of labor, is esthetically in review in this paper.

The esthetic development in New York City might be said to have started with the first World's Fair, which followed directly after the Exposition in London at the first Crystal Palace. To but few of us was this Fair a fact of which we had personal knowledge, altho the site is where the present City Library is now being bilt. The Architect, Richard M. Hunt, who rankt so high, and in whose honor we all, in our various Art Societies, contributed to erect a monument, came back from Paris the first of the so-called foren students, and, in sketch form urged upon the City authorities of those days, suggestions for the improvement of New York, one idea being for the entrance to Central Park at Fifty-ninth Street and Eighth Avenue, another for the entrance at Fifty-ninth Street and Fifth Avenue, and the third for one of the side entrances on Fifth Avenue. His suggestions were considered too grandiose, and remained but suggestions.

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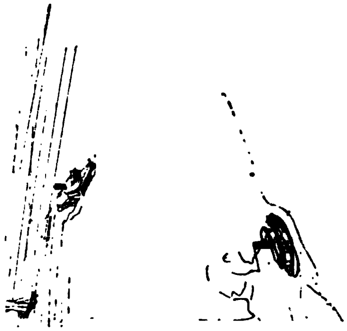
* Architect, 59 Carmine Street, New York City.

In England, Sir Christopher Wren, directly after the great fire in London, made an original plan, with his criticisms and suggestions for changing and improving the street-ways in London. Unfortunately, they never materialized beyond the map plan, and the narrow streets of London have remained from that time to this, as the problem for all City Engineers and Architects to wrestle with. It has been the problem also for the humanitarians to argue about, for congested blocks have been the difficulty of the housing problem in London, the smallness of the courts, and absence of light and air in the houses which face, not on the street-way, but actually on inner, dingy, unlighted, badly ventilated court-ways. That problem has been London's own, for there the citizens realize what death means as it stalks thru the narrow street. And they have tried to solve their problem in part by cutting out sections of the badly housed portions, and in re-erecting better houses in other parts of the City. At the same time the artists, led by men like Walter Crane, Sir Edward Burne-Jones and William Morris, especially by the latter, who was the head of the English Socialist movement among the artists, decided to make the central portions in the most congested district points of interest, as notably in the Picture Gallery down in Whitechapel, and it is well known that Whitechapel is a badly congested section and a plague spot to the police.

We, in turn, in New York, found our difficulties were much the same. The moment the situation became ours we acquired all the ills that accompanied it, and the first step that was made in our time was the cutting out of what is now called Mulberry Bend Park, thru the center of our own "Chinatown" and "Little Italy," which, according to the records of the Police Department, was one of the worst sections of its size in the city. This was the first step towards commencing to let light, air and sunshine into the congestion, unthought of by the earlier inhabitants. The only reason why progress was so secured was, primarily, because the argument was made along the line of the parks. It is somewhat peculiar that progress can be made in this city of ours, and in most American cities, by proposing parks and parkways, when nothing can be done by discussing streets, or architecture on streets, or other details of civic construction.

PLATE 34.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAMB ON THE ESTHETIC
DEVELOPMENT OF OUR CITY.



To those of us who are acquainted with foren cities, it is perplexing that the forener should have it so much better in his town, his metropolis, than we. Here, another suggestion was made and workt out thru one of the societies. At the time the writer was Vice-President of the National Sculpture Society, he urged the members to make sketches of ideas for city improvements. These sketch suggestions were made into lantern slides and thrown on the screen, and arguments and discussions followed from month to month. The sketches illustrating this paper are those of the author.[*]

Brooklyn Bridge and its difficulties, the end of Brooklyn Bridge for a grandiose entrance, the possibility of the use of tracks both ways, and of a large monumental staircase, presented an interesting problem. Of course this is one of the grand things for which the money can never be found, but it is, perhaps, nevertheless, interesting. Another was to rearrange Union Square by taking the statue of Washington, now poorly located, setting it on the axis of Broadway and face the monument down Broadway, where it would be seen from every direction and by all coming north. The line of Broadway was to be carried thru Union Square on the axis of the street from Fourteenth to Seventeenth Street, making not a street, but a mall, or a road for pedestrians, so that, for a regiment moving up Broadway, instead of flanking to the right or left around the Square, the march could be continued straight ahead. Still another design was suggested for the upper end of Union Square. Here the wide thorofare of Seventeenth Street seemed to afford an opportunity for a large open place for public debate, and it was almost at this point, actually in this square, that not so many months ago a mob was disperst by the police, and an individual killed in his illegal dynamitic protest against their way of handling the mob. There is much reason in the argument of the small boy, who is stopt playing in the streets, when he says, "Where am I to play? If you do not give me play-grounds, the street is the only place I have." His logic is unanswerable, and also that of his father who protests: "If you in authority in this city do not establish certain points at which public speaking can be permitted, then the street is the only place, and my rights are absolute." In London, it is possible to go to Trafalgar Square and to stand at the foot of the Nelson monument and say what you please. Also in Hyde Park, you may stand and speak at will, without being interrupted by the police or anyone else. Freedom of speech should have its possibilities, and it should not be necessary for some of us—possibly you and me—to be constantly forced to seek appliances, something that will swing us up off our feet, so that we are standing on cart-tails and are speaking on a side street, backt up to the corner, facing out on an avenue, by the permission of the police and not by right. (Plate 42.)

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[*] When this paper was presented before the Society. Mr. Lamb showed a very elaborate series of slides (some 70 in all) and spoke with reference to these as they appeared upon the screen. In reporting his statements it is difficult to have the reader understand the reference to them. Some of the more important views have been reproduced as illustrating this comprehensiv series of designs shown by Mr. Lamb.—Ed.

Longacre Square, before it was Times Square, permitted of suggestions which might do very well for the "Great White Way" of to-day, as we could erect the electric fountains suggested and convert it into a gala place for the evening, more artistic than the street with its present moving electric signs.

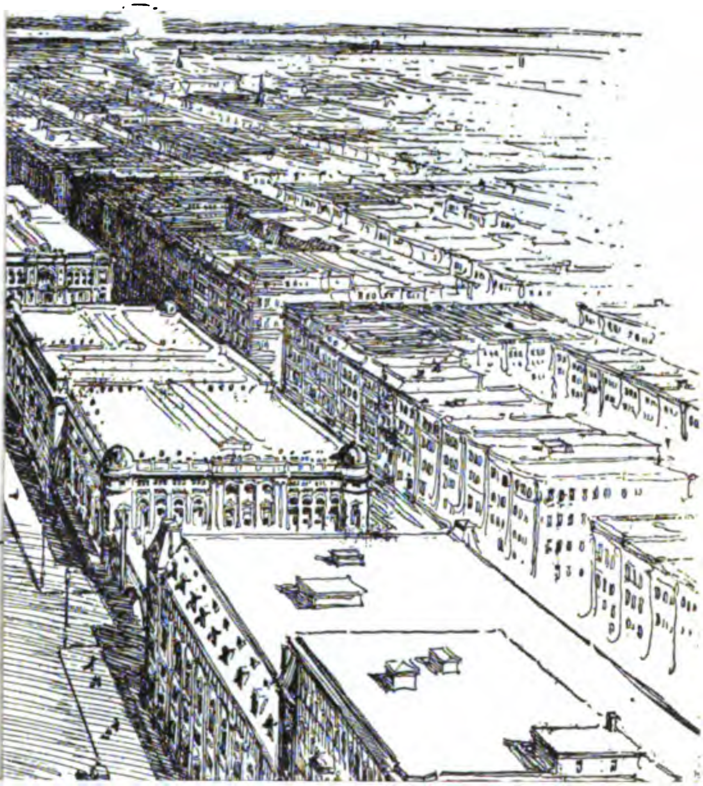
The southern end of Riverside Drive, because the Navy Department had establisht the anchorage for the Navy practically opposit this point, suggested the possibility of a water-gate and an entrance for the reception of our foren visitors by a staircase over the tracks of the old Hudson River Railroad, up the incline to Riverside Drive, an appropriate setting for a desirable entrance gateway.

Going farther north to Fort George—and this was before Fort George was the center of a summer resort—brought the suggestion of a possible incline up the hill, with a great tower and a light, to make an important beacon at the north of Manhattan, overlooking the Hudson on one side and the East River on the other.

Among the things which we did not suggest and the things against which we protested, was the work of the engineers. Among these were some of the projects of bridges across the Hudson as well as the East River. Along the line of other work of the engineers, however, our sympathies were strongly enlisted, and we reinforced their efforts wherever we could. We were believers in the great things possible for a great city, and recognized that the engineer was the only man to make possible some of the stupendous operations needed in the immediate future.

The home-coming of the Admiral, victorious in the Spanish War,

PLATE 35.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAMB ON THE ESTHETIC
DEVELOPMENT OF OUR CITY.



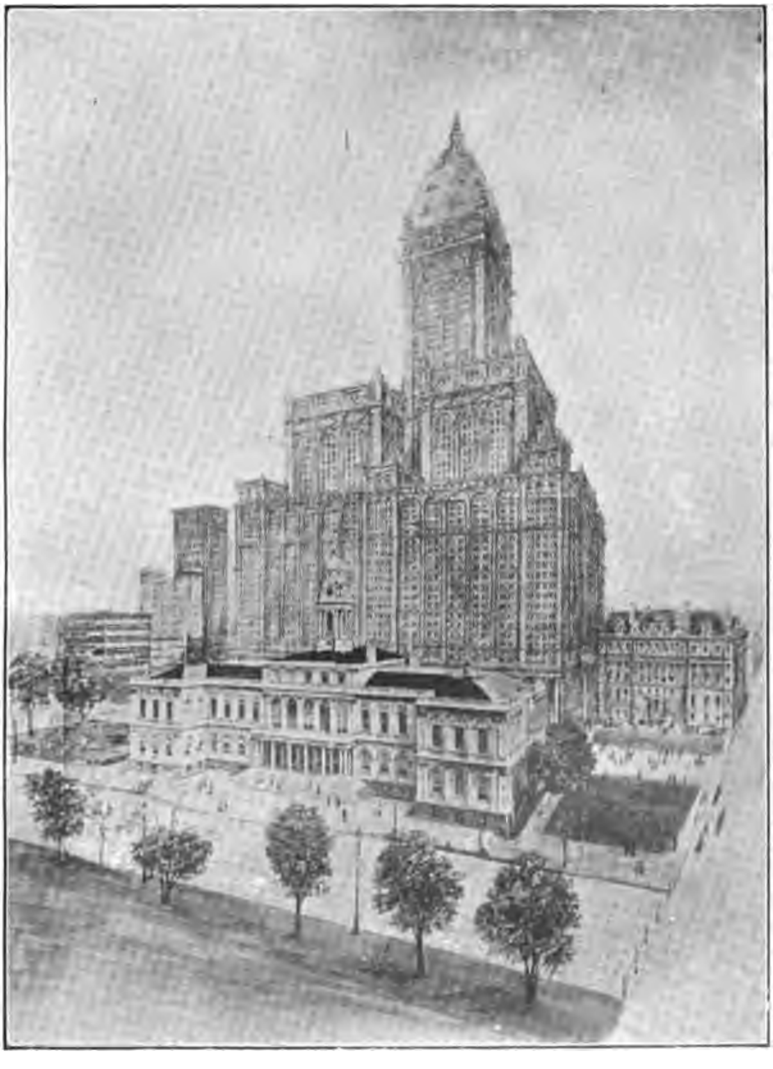
brought to mind the reasons why the city should do something, and converted me for the moment into an engineer, to locate, at the request of the City authorities, the arch Triumphal and the Colonnade. These authorities insisted that the position of the reviewing stand should determin that of the monument, and therefore the triumphal arch was erected in Madison Square on the axis of Twenty-fourth Street. The problem was how to make an arch which would look well from both north and south and yet not be as narrow as Fifth Avenue, which is 60 ft. from curb to curb. It was something of a satisfaction that, when it was erected, no one, I think, ever realized that the eastern side of the arch was on the line of the houses of the eastern side of Fifth Avenue, and not on the line of the gutter, and that it had been possible to take up, in the distance of two blocks, the extra twenty feet, by throwing the extra distance into the Park itself, thus increasing the arch to a proportion that made possible the marching flank of the regiments thru it, and gave, of course, the more grandiose proportions that were possible in an 80-ft. arch, rather than a 60-ft. one on the roadbed.

I was naturally met with all kinds of suggestions, and engineering friends came along to prevent my going wrong. The arch must be up in six weeks' time, and I was told I would have to dig down under the avenue and bild a complicated series of foundations, but I resolved that I would do nothing of the kind; "I will set it right down on the asphalt of Fifth Avenue and it will have to stay there," I said to myself. One of my friends came to me and said: "I think the wind will blow it up and down Fifth Avenue." He even wrote me notes, day after day, saying: "For Heaven's sake, don't have any such accident as that, for you will never live it down." I went to my drawings again. I was not an engineer and I did not see where the trouble was, but I tried one old, good safe rule, that of the equilateral triangle. I found, after all, that most of the measurements were inside the base, and the base was wide enough at the bottom. The arch did not blow up and down Fifth Avenue, and all I did was to nail it firm, instead of digging up the avenue and laying great logs and all kinds of similar combinations below ground.

I had also many other suggestions offered. They told me how to put the colums up so they would not fall over. One friend kindly sent me a system of cross-bracing, by which I could get the colums to stand up. I said: "My dear fellow, my colums will stand up. What is the trouble?" He replied: "Look out; they are tall colums, they haven't much weight and they have no base at all, and you are right on the curb." I said to him: "Have you ever been over on West Street?" He replied: "What has that got to do with it?" I answered: "Go over there and you will see a lot of telegraf poles. This is my series of colums. I simply put in telegraf poles and put plaster around them." Then the engineer went off and thought the artist was not such a fool as he had supposed, after all.

Then the citizens said: "That is so good that we are going to put it up in marble." This was what they said, but they did not, and the citizens, as a group, failed to secure this artistic monument.

There are, of course, absolute necessities to be met by the engineer, working out to a mathematical limit every square inch there is to be gotten out of a specific space, and the real estate, and the personal equation, take precedence over possibilities of City improvements. We were, naturally, advocating certain ideal things, losing ground very often, because we did not seem to succeed. Then, suddenly, in one case, we won, and the winning was largely due to the man who is now President of the United States, then Governor of this State. When we urged the preservation of the Palisades, just across the river, then being torn to pieces by the quarrymen, they were made possible as a great City Park, in spite of the fact that the other side of the river is in the State of New Jersey. The Park is for the City of New York, which was interested in the saving of those beautiful old roads along the river front of the Palisades from Fort Lee to Sneeden's Landing, a distance of over fifteen miles. This park became definit and possible largely on the initiativ of a few people, who thought the destruction of the Palisades shameful, and who brought about the appointment of a committee which visited Albany and urged on the State authorities, and then visited Trenton and urged this measure upon the New Jersey State Legislature, thus insuring the action of two States. Here, again, there were protests, but in this case it was not the engineer, it was the lawyer, who said to my brother who was activ in this measure: "What's the use of arguing?



Bilding for City Departments in North City Hall Park and Block North of Chambers Street. Suggested in 1898.

You can never do anything because it affects two States. The Palisades are partly in New Jersey and the upper end in New York State, and you cannot get concurrent action; it would not be possible to do it." My brother replied that he did not see why two Governors could not be intelligent at one and the same time. The lawyer said: "Even if the Governors are willing, they will have to appoint a Commission of New Jersey men in the one case and New York men in the other. That is to say, the Governor of New Jersey is going to appoint his Commission and the Governor of New York his, and the result will be that you have two Commissions and they will not work together." And this was stated by a very prominent lawyer as the insurmountable difficulty. My brother replied: "Can you tell me why Gov. Roosevelt cannot appoint five men (A, B, C, D and E) and the Governor at Trenton cannot appoint his Commission and also select A, B, C, D and E, the same men? These appointments, if you wish, form two regular Commissions, but as they are the same people they will not fight with themselves." The lawyer looked foolish, but that is actually what was done, and the Commission can legally be called two Commissions, if you will. The personnel is but one group of five gentlemen, and they are buying up and have been buying up for the last few years, all the property without condemnation and the park is practically an insured thing within but a few months more, there being but some odd pieces to secure.

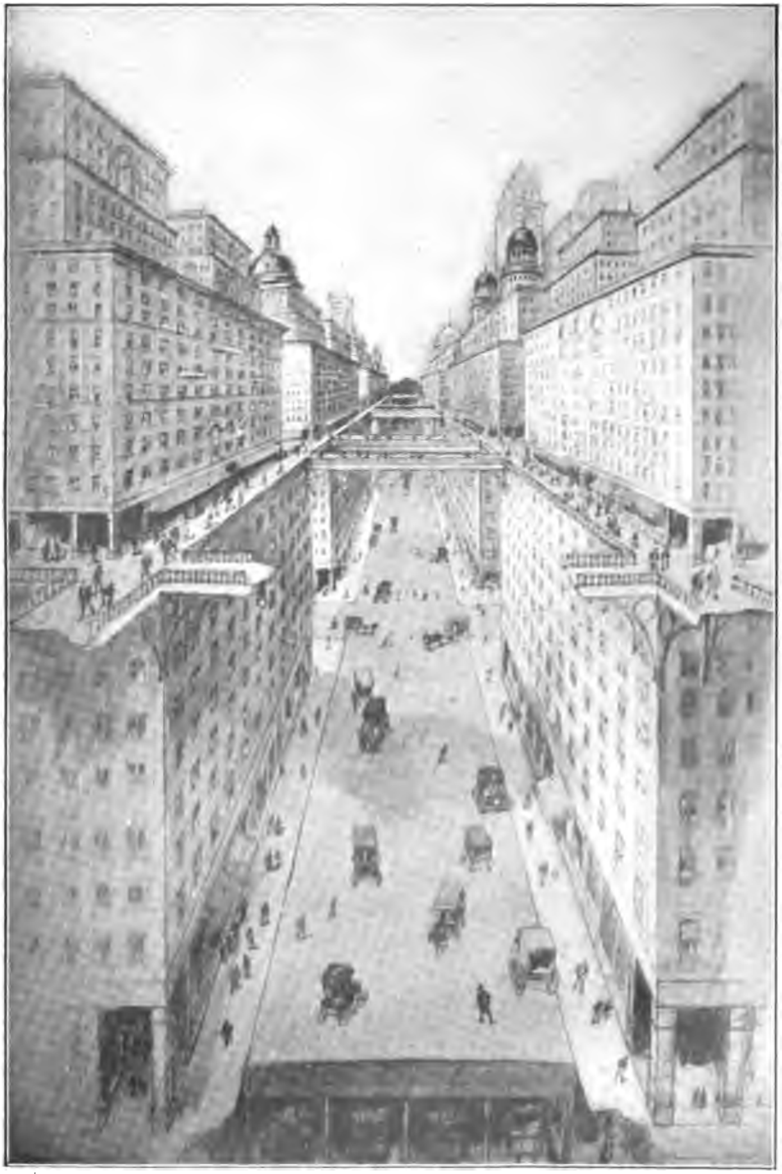
In the meantime the City Press has been taking up the subject and has been making suggestions as to following out the lines of many of our ideas, and been putting them before the public, thus describing all of these various things that are going to happen.

It the meantime, also, thruout the United States, this same attempt at improvement was moving forward, and we were called together, some of us here in New York, by gentlemen from the extreme west, with the request that we help them out with a grandiose scheme for a set of University bildings, the University of California. With practically unlimited money, the idea was to develop a great set of bildings for this University. Ultimately this developt into a competition and was won by a Frenchman, Besnard, and his plan on University Hill, overlooking San Francisco Bay, is now slowly materializing.

At the same time a Commission had been appointed at Washington to develop that city, which reported, as is well known, in favor of the original plan for the city. Washington is our most beautiful city, and the man who laid out Washington was not an architect. L'Enfant, the French engineer, who came over with Lafayette and the French Army, brought to our assistance in the Revolution, was selected by Washington, the first President of the United States, who himself was no mean surveyor, and probably was a pretty capable engineer, to develop the plan of the capital. All that the present Commission has done has been, practically, to go back to the original plan of L'Enfant and to urge upon the Administration the development of that plan and the obliteration of those bildings which have been allowed to creep in, to the detriment of the original scheme. The Washington of the future, to which the expenditure by the Government will amount to many millions, will be practically along the lines of the engineer of a hundred and odd years ago.

Just in passing, may I state that L'Enfant's grave is unmarkt, and that there has never been to my knowledge anything done to recognize the genius of the man to whom we, as a country, are so greatly indeted.

In the meantime it was necessary, of course, to keep informed as to what was happening on the other side of the water, and it is especially wise to study London, as a city of an English-speaking race, rather than a foren Continental city, and the various suggestions which have been made for the improvement of London streets. Their great difficulty might, of course, have been changed at the time of the great fire, but it was not, and the narrow streets remain to-day. In various parts of London there have been attempts to better conditions. One of the most important was that of Shaftsbury Avenue, which was cut from Charing Cross to High Holborn and thru one of their plague spots, Seven Dials. A monument was put up of the Earl of Shaftsbury, by Albert Guilbert, the sculptor, to indicate the improvement, and stands in the center of the widest part of the avenue. This improvement was secured by the City of London practically at no cost, and that is a point I would like to develop, the conditions they have in their law and the restrictions in ours. They have the possi-



ELEVATED STREET, AS DEVELOPT BY THE ANGLE OF LIGHT. SUGGESTED IN 1898.

bility of taking more land than is actually used by the improvement itself; in other words, they can condemn the land on a proposed roadway, and then re-sell the land facing on the roadway when bilt, and make the increast profit as a City, and those increast profits practically pay for the entire improvement.

We, also, realized our difficulties, and we thought they took the form of congestion in our traffic, so that we, the Municipal Art Society, presented an electrolier, and ile of safety to facilitate the traffic, and gave it to the City as an example. This example was followed by one of the departments, down on the Chelsea improvement, the same models being used.

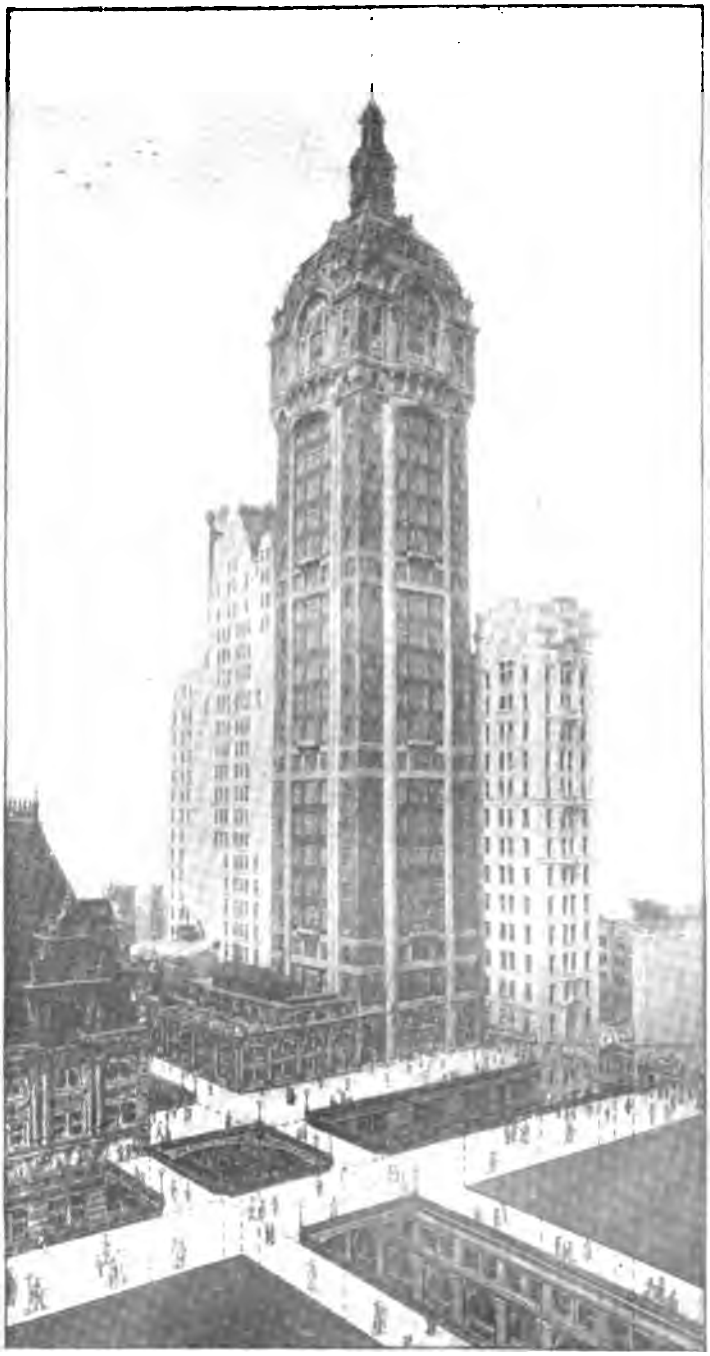
The more you study Manhattan, and especially the lower end of Manhattan, the difficulties become more obvious. You can see the tangled streets made by the old city as it grew out from the extreme Battery Point, and the lines which kept converging down toward this point and increasing the congestion. These problems, when they came up, were attempted to be met by the Municipal Art Society recommending certain things to the City Government of that particular time. For instance, when the Williamsburg Bridge was being completed, and the widening of Delancey Street not completed and was under discussion, we urged as a Society that instead of widening Delancey Street, to run straight over thru the Bowery or under Broadway, it should be made of two diagonals, one running up to Cooper Union and Fourth avenue, and one running down to the Bowery and connecting with the end of the Manhattan Bridge. But diagonal streets, for some reason, never seem to be of interest to the city administration, no matter to which administration they are presented, and inevitably the straight line from the end of the bridge was carried westward merely to increase the difficulties at the point where the widening stops. Instead of swinging the traffic to the northwest and to the southwest, as it wants to go, it is carried at right angles a little further west.

There was a suggestion to carry Christopher Street diagonally to Union Square. It was also proposed to extend Seventh Avenue, which now stops at Greenwich Avenue, and Sixth Avenue southerly, then to widen Varick Street and extend it northwest to meet the end of Seventh Avenue as extended. All this was put on maps, and advocated, and it was very recently that Chief Engineer Lewis, of the Board of Estimate and Apportionment, in his report, made possible at least two of these suggestions, the extension of Sixth and Seventh Avenues, and the widening of Varick Street, so that our recommendations have managed in some ways, either to be accomplisht in fact or in a modified form. (Plate 34.)

In the meantime London had not been content with Shaftsbury Avenue. This is but one improvement. Under my friend, Mr. William E. Reilly, now the architect of the London County Council, they tried to solve the difficulties encountered near the Law Courts, by securing a new large thorofare thru from The Strand near St. Clement's Church to High Holborn. This was supported by the Press and suggestions were made by many people. The plan finally adopted was a circular road, at one end intersecting with Waterloo Bridge, to form a base to the new "Kingsway."

The Act of Parliament that made this possible, if I remember rightly, gave the London County Council the right to close about twenty-odd streets, small places, and practically rearrange the map of London within the area of lines laid down in the Act. It also gave them the power to re-sell. The result is, this work, when completed, will be secured without cost to the City of London. It also afforded a very interesting opportunity for discussion as to how to design a series of new bildings on such a street-way, so that there would be a harmonious treatment of façades. Several architects made a number of varying suggestions, embodying their advice in plans, but, unfortunately, this idea has not been carried out. The London County Council found they could secure the sales of realty quickly, and they gave to purchasers the right of making their own designs, but with certain restrictions in regard to hight of cornices and projections of bay windows, etc., so as to secure a reasonable amount of harmony, if not absolute uniformity.

In the meantime we were going forward making sketches, and I, myself, have made a number. Among others, was one of how to prevent Brooklynites being cut down by the trolley cars at the Brooklyn Bridge entrance. (See Plate 40, Fig. 2.) The passengers now have to cross six lines of trolley tracks to reach their special car. The idea was to divide the passengers on the upper level, and bring them down directly to their trolley car at its turn. In other



THE ELEVATED STREET, AS ADAPTED TO THE PRESENT SINGER AND CITY INVESTMENT BILDINGS.

words, one came down the incline to his trolley car and not to that of somebody else.

Then there was the difficulty with trucks on Fifth Avenue. All of these suggestions antedated by some time what is happening today. The difficulty on Fifth Avenue arose from the difference between the house line and the old stoop line. It was proposed to take a block in which there are no high stoops and experiment by indenting the sidewalk. (See Plate 39, Fig. 1.) The interruption of traffic is not caused by the traffic itself, but by the standing vehicle which pulls up at the side and therefore cuts out two lines of traffic, one north and one south, one on either side of the street-way. Walks were to be cut back, leaving the corners as they were, but just indenting the block, and we pleaded with various Boro Presidents to indent just one block as a sample. We did not get the one block, but what we did get is the same thing. We are going to have Fifth Avenue widened all the way up from Twenty-seventh to Forty-seventh Street, or approximately two miles of avenue, as a beginning.

Angle streets seem to be my personal obsession—I am a believer in them, but never can accomplish their realization. Gridiron blocks, 800 by 200 feet, are not economical. I desired to give pedestrians a chance to walk from northeast to northwest, or the reverse, without having to make right angles all the time. When I presented this idea the answer was: "Yes, that will do, it's all right, you can get that." I cut thru one house, square the yard and then step to the east or west, then cut thru the house to the next street. I said that all those houses could be condemned, and was answered: "Oh, yes, that's easy, go ahead, let's start on it." Well, it is designed; now it is left to the authorities to put it in practis. (See Plate 40, Fig. 1.)

Then, of course, there was trouble downtown. It was proposed to close over Nassau Street and arcade the street. This seemed a good idea, so I made this suggestion for Nassau Street, where I secured an upper level for pedestrians to pass along and enter second-story shops as well as first-story ones. If you go up to the elevated platform why not go along. That was not carried out because, as was said, there would have been great difficulty in case of fire. So I made another sketch showing a roof 100 feet above the street. I was asked: "What are you going to do with the bildings that are not as tall as the highest one?" The answer was: "That's simple, you close down the sides of the arcade until the other one grows up to it." (See Plate 43.)

Then I developt the idea of a roadway around the iland, which will give a thorofare for automobiles and bicycles as well as for pedestrians on the upper grade, will carry the elevated road on the first level and clear off from along the East River and on West Street practically everything but what is now needed for the delivery of freight on the docks. It will also take freight from the docks into a lower level, and run it thru underground. This, one of my best arguments, I presented to four different Dock Commissioners, one after the other, only to have it objected to by all.

The fact that New York is a great commercial City is undeniable, and also that we want to keep it so. Nothing is to be gained by ignoring the other fact that the absolute number of running feet of river front is a fixt quantity. It is very well to demand recreation piers. I myself never clamored for them, but I believe in the principle. But when it is considered that the recreation piers take out so much from the commerce of the City, the necessity for them may be douted, especially when the cost for each amounts to about a million dollars. This makes us think of the Tax Department and the tax list. It is possible to have a recreation pier at every pier, and all that is necessary is to write into the contract with the Steamship Company, when renting, a clause reserving the roof for the use of the public and providing that it shall be flat and not pitcht. Many reasons are given why this cannot be, but there is no real reason. All that is necessary is to have some Dock Commissioner with the courage to write contracts that way, and he will be the most popular Dock Commissioner New York ever had. The river belongs to the City, and there is no reason why the river should be shut out from the citizens. What is being done in the Chelsea so-called improvements, the shutting out the river from the citizens from Fourteenth Street as far as Twenty-third Street, is practically a crime against the public, and it is absolutely unnecessary, because all that is to be done is to open the upper levels of the piers to the people.

In England, when the Prince Consort died, they memorialized him by a great monument in Hyde Park, with which many of you may be familiar. An architect was called upon to design a fitting

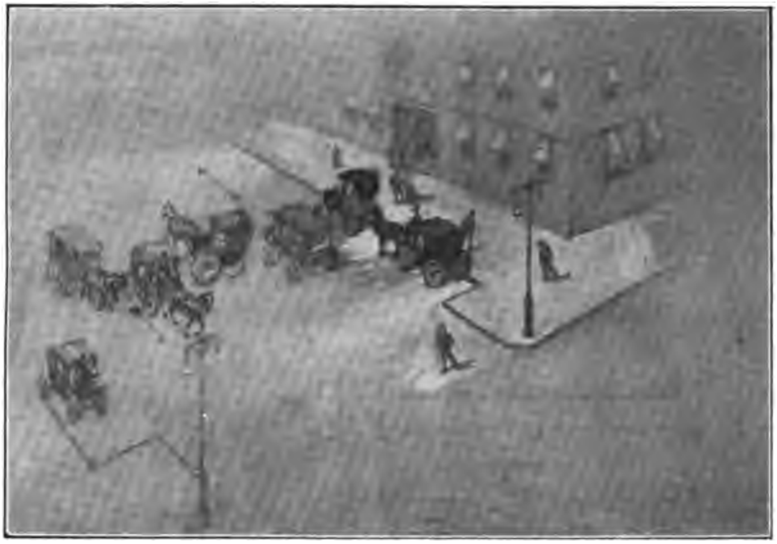


FIG. 1.—THE INDENTED BLOCK, TO RELIEVE TRAFFIC ON FIFTH AVENUE.

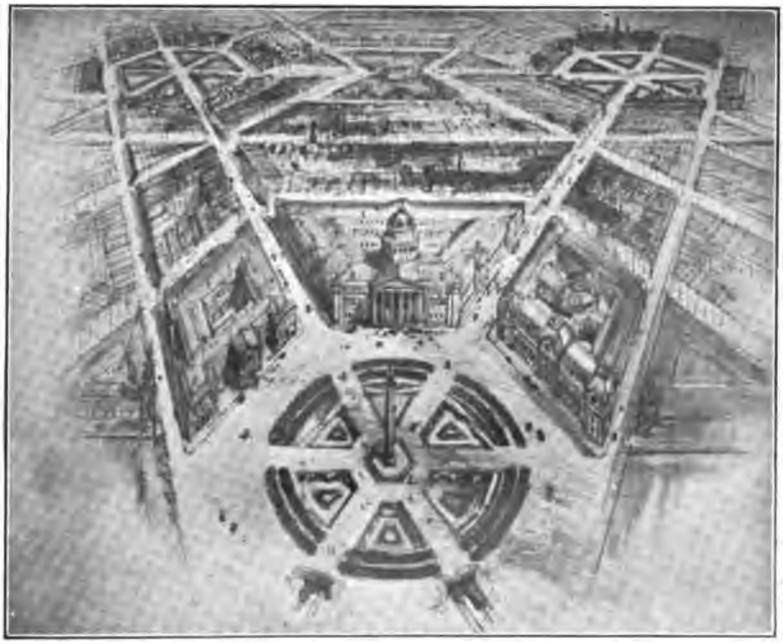


FIG. 2.—SUGGESTION FOR A NEW CITY, BASED ON THE HEXAGONAL SYSTEM OF STREETS.

memorial. It was only a monument set in a park, better and finer than many of our monuments in Central Park, but still only a monument. It had nothing whatever to do with the City, that is, the City itself. In the interval of time between the Prince Consort's death and that of his wife, the much and greatly beloved Queen Victoria, the English mind had changed, so that when they came to consider a memorial to their Queen, it took the form of a great road or parkway from Charing Cross to Buckingham Palace, and connected by this great wide roadway, the monument is set in front of the palace, on the axis, so that it can be seen from Charing Cross. The progress made is evident to-day, the Englishman is thinking of his beautiful city, and the improvement of his city, and the responsibility in such improvements of all citizens. In the meantime we, too, have been thinking, and the engineers have been at work. The bridges scheduled for the East River have, among others, the one on Blackwell's Iland. When completed, with all the extra traffic which must come across it from east to west, the outlet will be far too narrow. On our part, we made one suggestion, a tentativ one, that the Netherlands Hotel should be arcaded on its ground floor, and the street widened by the width of the sidewalks, the gutter being carried over to the house line of the Hotel. The right of condemnation was admitted by the lawyers to be undeniable, and it would not change the architecture of the bilding at all; it would only narrow the ground floor the width of the sidewalk. But this did not seem to be sufficient, so one of my friends, who had been a resident in that quarter some years ago, came to me and proposed that we "Cut it right out." I asked his meaning and he replied: "Let us suggest a general good scheme and put it right straight thru; cut out the whole block, from Fifty-ninth to Sixtieth Street. There is the so-called Millionaires' Club here; we will run it straight from Fifth Avenue to the east, to the end of Blackwell's Iland Bridge, and put here all these City bildings, or some City bildings, as interesting features of the scheme." So we developt it and planned the big bildings on both sides, and proved to our own satisfaction that it would be a paying investment, if the various interests would only co-operate intelligently. We made a skeleton drawing (Plate 35), demonstrating the possibilities of satisfactory financial returns and we indicated the artistic advantages to be obtained. We also endeavored to prove to the gentlemen living north on Fifth Avenue, in the Millionaires' Row, that unless they put in some such buffer between themselves and the march of progress north, it would not be very long before business would take Fifth Avenue in the upper part, running from Fifty-ninth Street north, away from them, as it is taking it away from those like William H. Vanderbilt, who put their houses south of Fifty-ninth Street. It is reported that the late William H. Vanderbilt admitted that he had made a mistake in taking Fifty-third Street as his home, and that he should have gone north of Fifty-ninth Street, but the same difficulty will be experienced by the residents north of Fifty-ninth Street, unless they have some buffer to protect them, or unless they make Fifty-ninth Street a parkway. A park is a most beautiful thing; a park will interrupt lines of traffic, will interrupt lines of business, when nothing else will, and a great wide parkway of this sort would do that. We did not make any progress as far as our suggestion went, but when, under Mayor Low, we urged the Mayor to appoint a Commission to improve the City and consider these things, he asked my brother, who was then Secretary of the Municipal Art Society, to show him some of the schemes, and my brother codified all the ideas which at that time had been formulated.

The Boro President, Jacob A. Cantor, put a bill thru the Board of Aldermen appointing what was known afterward as the Public Improvement Commission, and Mayor McClellan appointed a Commission, of which Mr. R. K. Pendleton was Chairman. They made a report, which I believe has been generally read, and many suggestions, including among others this wide parkway. But the difficulty, of course, with New York is a geographical one, and the fact that business will, in spite of all the impediments to traffic, be done at that southern end of Manhattan Iland, and will be concentrated there, owing to the hight permitted all bildings in the lower part of the City. To my mind, it will never be possible to enact a law absolutely restricting the hight of bildings. There is sitting at present a Commission to discuss the revision of the Bilding Code. The Commission which sat just before this one reported a suggestion in regard to the hight of bildings, and it has not been acted upon, and it is questionable—no matter what hight may be

PLATE 40.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAMB ON THE ESTHETIC
DEVELOPMENT OF OUR CITY.

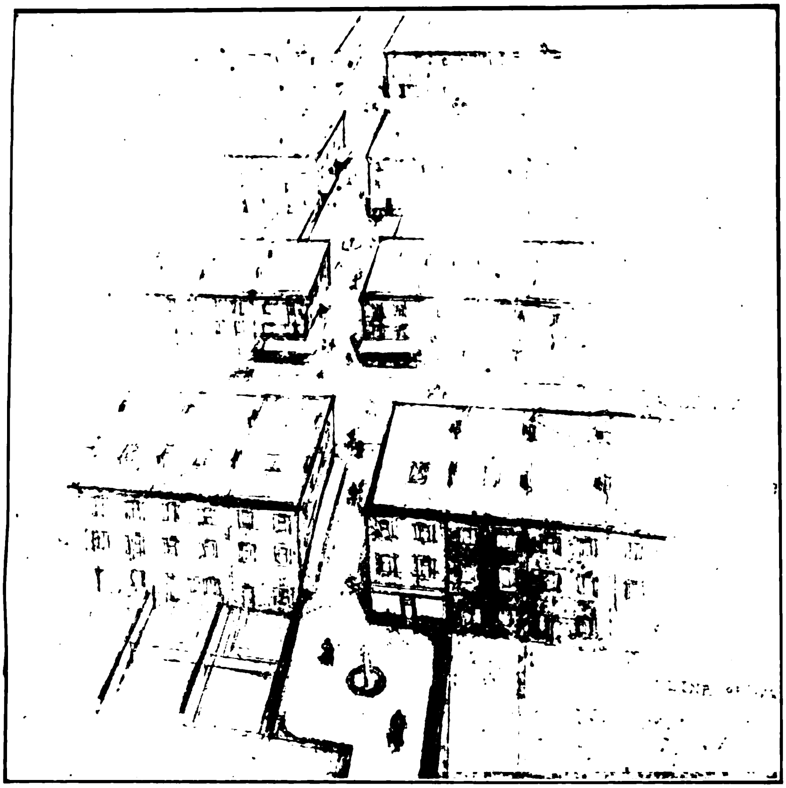


FIG. 1.—INTERIOR STREET BY SYSTEM OF STEPS TO EAST OR WEST TO GIVE DIAGONAL PASSAGE TO PEDESTRIANS.

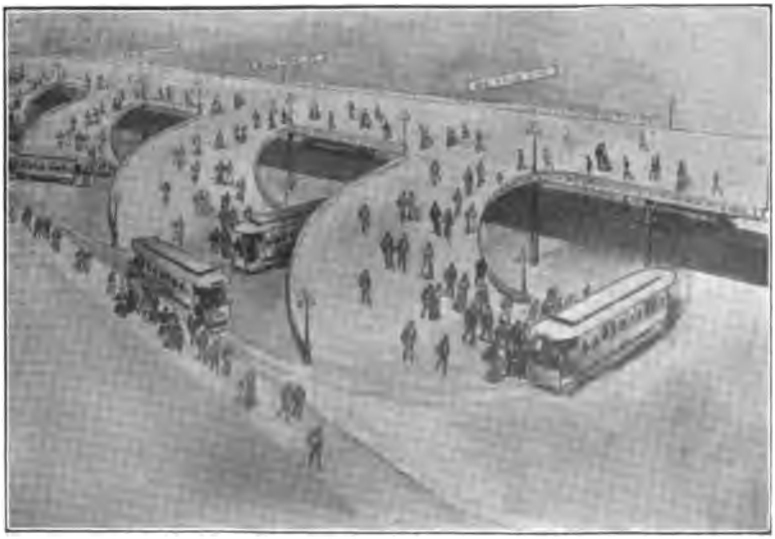
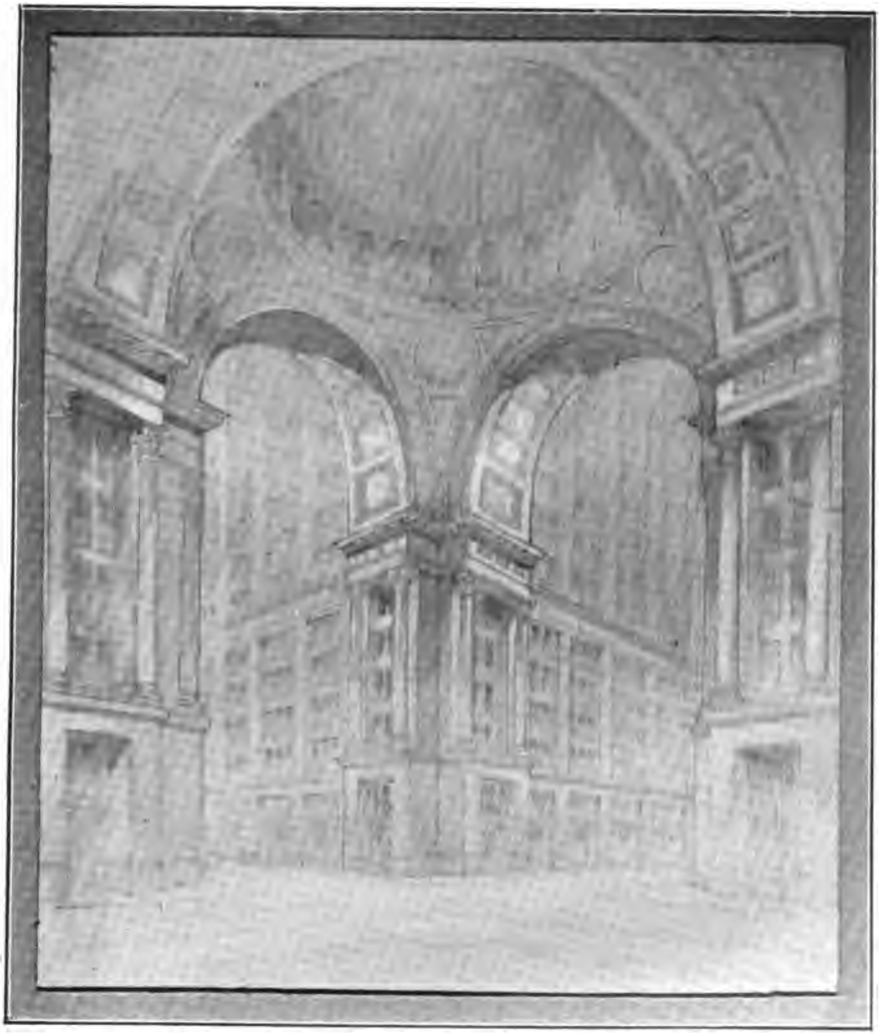


FIG. 2.—SUGGESTION FOR DISTRIBUTION OF TRAFFIC AT BROOKLYN BRIDGE.

specified, 200, 300, or 400 ft.,—whether it will be possible to get concurrent action in favor of an arbitrary flat measure. This being so, reflection is due on the greatly changed conditions in New York, since Bowling Green was the heart of the city, to these days when tall bildings are absolutely too common here,—this reflection led to the suggestion which I had the honor of laying before Boro President Coler when he was Controller, that he should advocate a bilding for the City which would be big enough to solve the situation. I represented to him that the total rent paid by the City Departments in bildings not owned by the City would represent when capitalized at a 4% investment an amount sufficient to bild a municipal bilding worthy of the metropolis. This he admitted. He found, I think, when he commenced to figure it up, that he has some $300,000 in rents alone. (Plate 36.) When he asked me how tall the tower was, I said 750 ft. This was before the Singer and Metropolitan Life bildings were erected. It was ten years ago, and it was ridiculed. I arcaded Chambers Street and ran another arcade north to Reade Street. (Plate 41.) What I had in mind was this:—I wanted a bilding so big that it represented the City of New York, not a Life Insurance Bilding, or a Sewing Machine Company, or anything else. It is a number of years since then that Ernest Flagg put up the Singer tower, and yet I assume he is about as disappointed a man to-day as there is in the city, because his beautiful scheme is so greatly injured by the City Investment Bilding. The great difficulty is that the individual right of the owner of property has no restrictions upon it. He can do what he pleases. In this case, the City Investment Company backt right up against Flagg's strong tower, and congratulated themselves that the wind pressure was all right on that side. There they are and there they will stay; and the result is, the two bildings curse each other architecturally. The whole thing is an absolute fiasco from any point of view. The Singer Bilding is blanketed on two sides, as far as light is concerned, and the artistic result is disastrous. There is no reason why the expenditure of millions of dollars should continue so as to destroy the entire sky line.

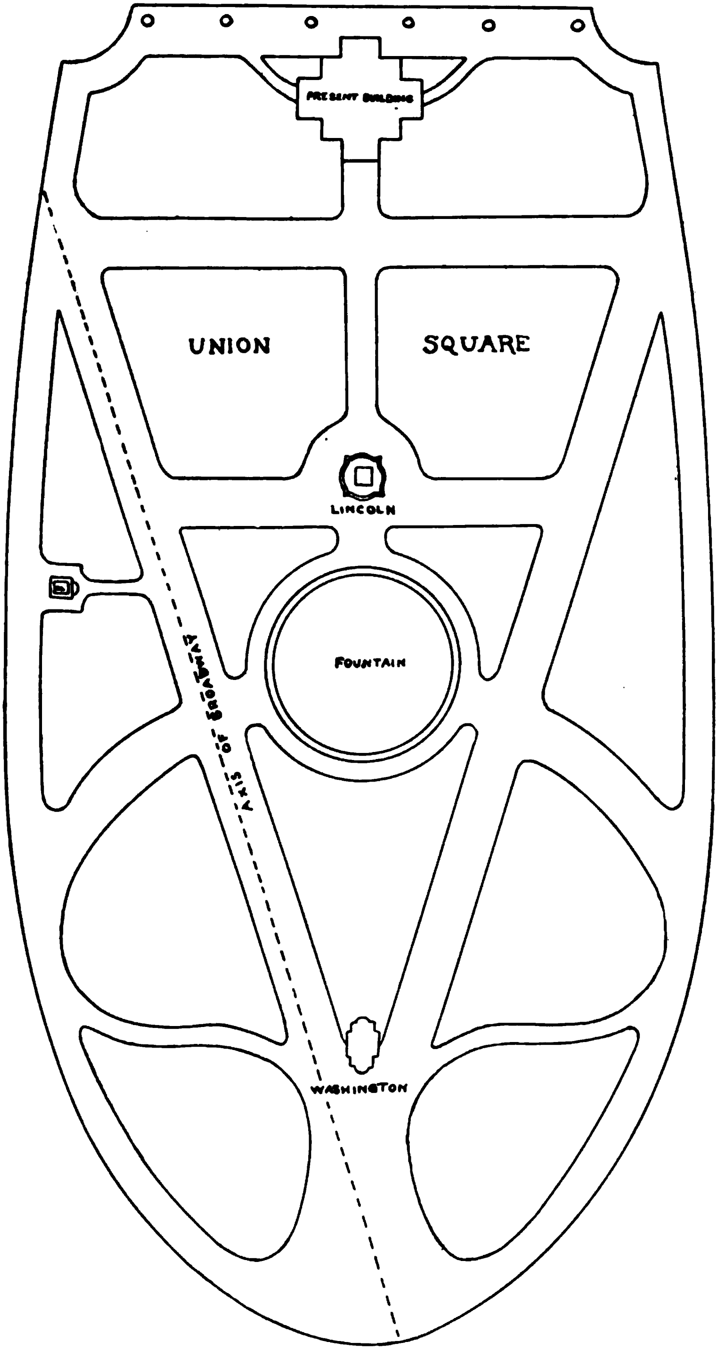
There is another example near the same place downtown, which is to my mind one of these tragedies in architecture, on the site of the old Herald bilding, at Ann Street and Broadway. The architect, Mr. Post, drew up a scheme for the entire block (two pieces of contiguous property). The owners were consulting together that they might erect a bilding which would present a continuous effect—the bilding to be a mass from the corner of Fulton Street to the corner with the angle of Broadway and Ann Street. Those who controlled the Fulton Street property could not agree with the Ann Street property interests, so only the Ann Street end was bilt.

In regard to the difficulties of light, the Frenchmen have a solution by what is called the "angle of light." The angle of light to the street bears a relation to the width of the street. It is forbidden to bild the façade of a bilding beyond what the angle line, falling on the opposite sidewalk, would indicate. From this came the Mansard roof, the roof that pitches back as it rises and afterwards receives one, two or more dormer windows, but always beyond the angle-of-light line of the street width. In our case, it seemed to me it would be possible for us, also, to establish an angle-of-light line for our streets, but to develop it in a different manner. The very high bildings are inevitable; the only thing to be done is to control their hight, and my plan was to so regulate it that it would always be inside of this angle, so that the tallness of the bilding would recede toward the center of the block, and thus make possible this other idea—the upper street. To my mind, this is the only solution, and I believe it to be the coming one. This measurement from the cornice on the façade of the bilding line, the present bilding line, can be establisht arbitrarily at any hight desired, we will say, 150 ft. The bilding is then stept back and carried higher. By stepping it back, the upper street-way is provided for, and the result will be that if this is connected corner to corner, we will obtain a workable scheme. It would be found advantageous if applied only to a single block, as it would save the descending in elevators and the ascension again to the tops of the bildings. It will be quite possible to develop this block by block, as the bildings are erected. It will also open up an entire new line of offices and stores for the lighter trades—the restaurants, tobacconists, candy shops, and most of these that are now seen on the lower strata would inevitably come to the upper. The pedestrians would move along these aerial promenades as freely as on the earth below. (Plate 37.)



Arcade in Suggested Bilding for City Departments, Showing Chambers Street Running East and West, and a New Street North from the City Hall to Reade Street, Under the Axis of the Central Tower. Developt in 1898.

PLATE 42.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAMB ON THE ESTHETIC
DEVELOPMENT OF OUR CITY.



Suggested Rearrangement of Union Square.

The lawyer, of course, interposes objections and inquires as to what is to be done with the bildings already erected. My reply is, to condemn a right-of-way thru the bilding at the hight of your street. In other words, if the hight is 150 ft., at 150 ft. you go past the face of the tower of the Singer Bilding, and by an arcade thru the City Investment Bilding north. (Plate 38.) I contended that it was just as simple to condemn it at that hight as on the ground level, and this was admitted. The law can be met with any theory, if you are only insistent, that is all. To the constant objections of my legal friends, that the thing is not legally possible, the reply is, that whenever there is a demand by the people that the laws be changed, they are changed, whether by revolution or otherwise. Afterwards, there is no difficulty in finding new lawyers to write the new laws, or the old ones to modify their ideas.

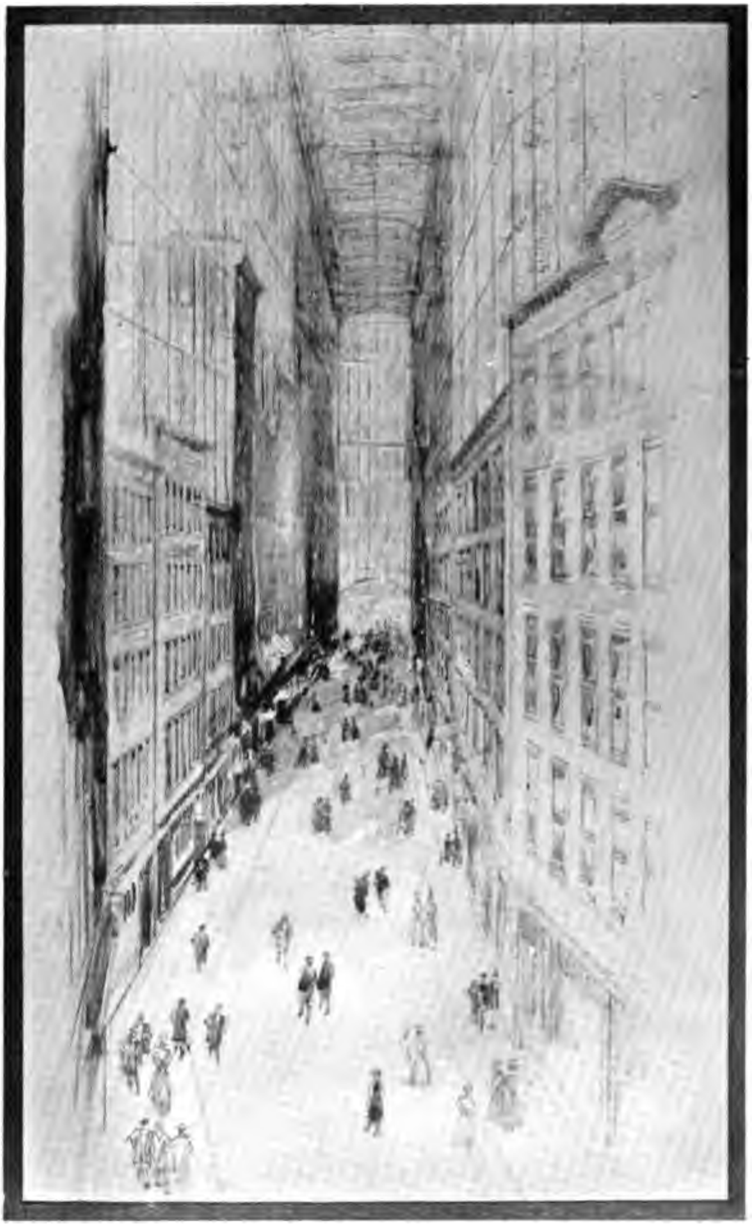
But our trouble is what? The fire of London did not help London, the fire of Baltimore did not help Baltimore, nor Chicago, Boston, nor even San Francisco, because the moment that the fire is over, the laws of realty are still adhered to and the individual starts bilding up again exactly where the line was before. Now, the difficulty is this: There is no preconceived scheme for improvement; there is no map laid out to show that when we can we are to improve along pre-arranged lines. In Paris, for example, you will find a street that runs wide a certain distance and stops; then there is a blank wall, the side of a house. You may come back twenty years after and still find the blank wall. I asked a French friend why. He replied: "My dear fellow, that street is going to be widened to that width some day, but as to the owner of that house, we do not penalize him; when he realizes that it is to his advantage to take it down, we will take it at a valuation; if not, it will be taken in so many years after the map is establisht."

Now if there were maps for all cities showing improvements planned, then when a great calamity happens, it would then be possible to say, we will now establish such a street 60 ft. wide instead of 40 ft., or 100 ft. instead of 80 ft., and the improvement will be carried out at once, instead of always, as now, in the most expensiv way, and, in certain cases, so expensivly that they have never been put forward, because, really, our difficulty is that of cost. Unless we make our lawyers realize the possibility of the English system, and adopt it, we cannot stand the pace. Statistics in our daily papers show a tax rate of $175 to the average family. The expenditures of the City, to which we all are contributing, are greater than the expenses of any State Government in the United States, and are second only to the expenditures of the National Government itself. And what are we getting for our money? We call ourselves a business people. We say we are a practical race. The facts are, that the Americans, with all their "hustle" do not know how to get a hundred cents for their dollar, and never have known. Our forener, both Continental and Englishman, carries on his improvements in his City without increasing the tax rate, and they are very much finer, better, and more superb in every way than ours. We make a great effort and we try to do what some dear lady friends did on the West Side,—get a little park over in Chelsea, and when after great effort they secured a small City Park of a block square, the cost practically increast the det limit $1 000 000. Perfectly preposterous! And everybody who has been on the inside and has acquired a piece of property is making a profit, whereas, if condemnation had been possible for that City Park to the center of the block north and south, and the property facing out on the new park re-sold, the park would have been bilt for no cost and the tax rate would not have been increast.

These are the difficulties which are practical. They are not difficulties with which private individuals or City employees can do anything, but they are difficulties which individual citizens can, thru their own efforts, in their own parties and with their votes, help to ameliorate. The Municipal Engineers, as a body, can establish a point of view, and bring these questions to the attention of the municipal authorities.

It is distinctly to our advantage to have a great city and a beautiful city. It is distinctly to our advantage, absolutely in dollars and cents, to have everybody coming to New York because they want to see New York. Why have our hotels grown up like mushrooms, over night? Why is it that in one block on the "White Way" there are eight theaters, and forty theaters in the area of a mile square? Surely, not because the residents of New York are going to those theaters constantly! Not at all. The hotels and the theaters are an index of the number of people who think it worth their

PLATE 43.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LAMB ON THE ESTHETIC
DEVELOPMENT OF OUR CITY.



SUGGESTION FOR ARCADE COVERING THE NARROW STREETS OF LOWER NEW YORK BY STEEL CAGE AND PLATE GLASS ROOF AND SIDES.

while to come to New York City, and they come because they want to see the greatest city in the Western World. We are going to be not only the greatest city in the Western World, but practically in our time, in the time probably, at least, of the youngest men here, the greatest city in the world. If it were possible to get over state lines and count as an integral part of New York, which we have a perfect right to do, all that territory in New Jersey, Jersey City, Hoboken, the Oranges, out as far as Montclair, to include all that in our population, just the same as Greater London takes in its surroundings, we would come near to being Greater London now, and we will be greater than London as a city in a very few years.

We are not, as a city, fully realizing our responsibilities; we are letting individuals, thru persons, corporations, railroads, great groups of capital brought together thru the concentration of some particular interest, dominate certain parts of our City, when we should, as citizens, by establishing a system thoroly workt out, have them contribute intelligently and with the idea of a complete unit to the greatness of the City. It is not possible for us to plan our city *de novo,* as I did in proving the stupidity of our gridiron street plan by the idea of a hexagonal plan (Plate 39, Fig. 2), but it is possible for us to modify the present conditions so as to make each change a change for the better, and each step a step forward.

These may, perhaps, be considered platitudes. Hardly that; they are not mere ideas,—they are something in which everyone is interested in working out. New York really looks well only at night, when it is possible to forget, in the shadow, all the edges that are not filled up. But, in spite of all the difficulties, this is our field of work. To those, like myself, born here, to those who have come here, New York is where we are going to work, and it is for us to see that New York is the best that we can make it.

DISCUSSION.

Mr. Robert Ridgway.—We are surely indeted to Mr. Lamb. His paper is of intense interest to us all, not only as engineers, but as citizens of this great city.

I would like to call upon Mr. Tuttle to give us his ideas upon this subject.

Mr. Arthur S. Tuttle.—We all recognize the author as one who has been activ in educating New York people to insist upon public improvements being planned on an adequate scale, and in such a way as to include artistic merit as an essential feature. The educational process has been a somewhat expensiv one, since art, in public work, was originally considered a luxury chargeable wholly or in large part against the entire City, and under conditions which would permit of payment in small installments running thru a long term of years. In a similar way parks and boulevards have largely been secured, and that the method of securing them has proven satisfactory to the taxpayer is evidenced by an ever-increasing demand and an entire absence of protest. That the city treasury has permitted of carrying out only a small part of the improvements desired for the adornment and growth of the City has been clearly shown by the author, and that the past recognition of the demand has been too great, is establisht by its present condition.

The present trouble appears to be due to the fact that we have tried to provide improvements of a character heretofore considered such as should be paid for by the entire City at a rate greater than that justified by the increast valuation of our taxable property. I think there is no question but that every dollar expended in adornment and in making provision for future growth will come back to the City many fold, but the problem with which we are now confronted is where to raise the money with which to pay the cost of desirable improvements of this character. If this can be solved, one of the most serious obstacles to progress will have been removed.

The author has cited the case of the proposed southwardly extensions of Sixth and Seventh Avenues as an illustration of a needed improvement now under consideration by the city officials. An examination of the city map will readily convince one that this improvement is a logical one, and familiarity with the area affected seems to justify the belief that if these streets are properly opened up to traffic they would rejuvenate a district which has in no way responded to the metropolitan development which has taken place on all of its borders. The project is a very old one, but the cost of breaking thru the succession of blocks has been deemed too great to admit of serious consideration. The recent revival, however, has been coupled with a suggestion that the cost of the improvement be assest directly upon the property benefitted. The estimated cost of the land and bildings required under the most feasible plan is nearly $7 500 000, but there is little dout that property values in the area affected would respond at once, and that if treated in this way the money could be raised without serious hardship and without injustice.

It seems more than probable that for many years to come our large improvements will have to be planned along lines similar to those suggested in this case, or that an allowance will have to be made in the annual budget for the amount needed to defray their cost, or possibly a combination of both plans may be resorted to.

In levying assessments for improvements we are forced to recognize that property seldom fully responds at once to those of large magnitude, and for this reason if owners in the district benefitted are not to be subjected to hardship, a combination of the two methods of raising funds might prove desirable.

Mr. George W. Tillson.—I have been very much pleased, interested and instructed by the talk that we have had here this evening. It is certainly one of great value to us all, and it is broadening to the engineer, because while both the architect and the engineer deal in public improvements, they do it from different standpoints, and it is a fact that all work too much from their own standpoint, without giving proper thought to other people, who, while perhaps not interested so much on our side, are interested in the results as a whole.

The architect in working out his schemes is not bound down to cost as the engineer is. The architect must produce a beautiful effect, and if he produces this effect he does, as a rule, produce what his employer asks for and what he wants. The engineer, on the other hand, is bound to cost and he, in common language, "has to make good." He is working on a commercial basis, and he must work up a scheme that will bring back to his employer interest on the money invested; if he does not do that he is not employed again.

Now it is also a fact, as has been stated by the previous speaker, that all the engineering projects that are proposed for New York City to-day, must have their artistic side, and the engineer, when he presents these projects, wants them and must have them presented from the artistic and architectural standpoint. At the same time, however, we want the architects to work a little from the engineering standpoint.

The author referred a great many times to England, and to what they did there. I am sorry that I have not had an opportunity of traveling in the old country and seeing these things, and for that reason I dislike to say anything against what has been said in that connection, but I would like you all to realize how long they had been thinking about these things over there before they accomplisht them. I have had occasion to look up some of the history of the improvements on the other side in my own line of work. London had a population of 100 000 people and Paris 200 000 before they had any pavements. In 1826 an engineer who had been investigating the pavement situation on the Continent, reported that in the principal cities in Italy, the streets were paved with cobblestones with two lines of broad stones in the center for wheel tracks, but that this was too expensiv for the City of London. For that reason I do not like to say anything against the comparisons of this country and the old, but I must confess that when this country has only been settled as short a time as it has, when in the memory of some of our present population this city did not extend above Canal Street, it does seem to me that the criticism is a little too harsh and that it is expecting too much to have such improvements in this country as they have in London and Paris, where they have been working so many years, and where they do not have such a constant change and growth as we have here. Here we bild to-day a ten-story bilding and tear it down to-morrow to put up a twenty-story, and the next day tear down that twenty-story to put up one of forty stories. When conditions in any city or community are such that it is a commercial proposition to do those things, I think that it is impossible to expect such a city to keep up the artistic side of everything while we are working them out on a financial basis.

Mr. Alfred D. Flinn.—Mr. President: What Mr. Lamb has said has emphasized a genuine municipal want, the need of a consistent and comprehensiv scheme of development and improvement. As Mr. Tillson has just pointed out, with a city growing so rapidly as New York and many other American cities have been growing, it is difficult to get the persons controlling the administration of these communities to realize how big their schemes must be for a reasonably distant future, or to plan adequately for even a few years in advance. We have learned from European experience that such schemes have to be laid a great many years in advance to be fully effectiv in some lines of municipal development. Furthermore, the administration of public works is, in many places, too much divided, without co-operation among the departments. Speakers at the last annual dinner talkt in a somewhat similar vein of the development of New York City and the failure to realize its possibilities.

This society of engineers can, in a measure, counteract the lack of official co-operation in the administration of Greater New York's public works, for the engineers are—or may be, if they will—the real directors of the public works. The Municipal Engineers, too, have certain powers as a mover of popular sentiment. We cannot, perhaps, directly start any of the much desired improvements in administration, but each of us can be thinking, and when we do have the opportunity, either as individuals or as a society, to give impetus to a good cause, be ready to recognize it, and express ourselves intelligently toward a definit end. We can promote harmony and a spirit of co-operation among ourselves in the carrying out of city works, and bring the persons who are directing the administration of public affairs to appreciate what are technical questions and to leave them to technical men, whether architecture or engineering, or landscape work. I am not ready to start a reform, but would make a suggestion. One frequently sees a pavement recently finisht torn up to lay a water main or sewer, and it too commonly occurs that some extensiv improvement is carried out with small regard for related works which will follow. The wastefulness of such operations is pathetic to any citizen even half concerned for the City's welfare. In part the responsibility for this lack of co-operation lies at the doors of the engineers and architects. Can we not at least partially control this situation with some patient endeavor?

A right-minded engineer in a responsible public position, if he has an adequate conception of the dignity of his office and the real power which inheres in it, can, by diplomatic suggestion or skillful management of men as well as things, accomplish much, especially if he does it quietly. He can at least help to guide the commissioner, or the board, or the boro president to a wiser use of the City's money. Why cannot the engineers of the various branches of the City government keep one another informed of proposed undertakings, even before they assume final form, thru the bulletins of this society or other similar channels? And why should not two or more of these engineers get together when they find that their plans are or may become related?

MR. WALTER G. ELIOT.—I know of no great public improvement system or plan for beautifying, that ever originated with an engineering society. That is doutless due to the diffidence and general modesty of the engineering profession. But there is no man in this society, who has intelligently read of the occurrences in this city during the last decade, who will not admit that the architectural and artistic societies of the country have done a great deal towards improving and beautifying. Mr. Lamb's own society, an organization more successful in that work than any organization ever founded in this country, has been the means of the adoption of more practically esthetic ideas of beauty and good taste than all other societies or politicians combined. Under Mayor Low's administration, and those that have succeeded it, these ideas have borne fruit. It resulted, for instance, in the condemnation of certain plans for bridge approaches, court houses, and other things of that nature.

It has certainly, as the previous speakers have said, educated the people of New York to the fact that the artistic side of public improvements must and shall be recognized.

But there is one point that Mr. Tillson made which I think is not justified, and that is that because London is 1 000 years old and was able to do nothing without thinking it over for 400 years, it is no precedent to be cited for New York, for the reason that in the short time that this city has existed it has grown fabulously in wealth during an era of the greatest advance in money concentration known in the world's history, so that while London may have had a long time in which to do its work, this city has to do it a thousand times more rapidly. As an illustration of the folly of dallying along with improvements, the necessity for which is instantly self-evident, I will say that within the last three years my work has been largely cast in a boro where the greatest crime has been committed by neglect to do the very thing that Mr. Lamb has shown to be practicable. It has been brought out by Mr. Frederick Olmsted and a number of other people of mature thought and experience, that the plan of condeming more land for a park or a boulevard than was necessary for the actual boulevard or park, would have given those parks and boulevards to the city practically for nothing. It has been absolutely proven in the Boro of Queens, because the increase in the value of the very property suggested for parks which could have been bought two years ago, has been so great that the upland to be bought for parks could have been sold for enough to have paid for all the parks needed, for more parks than we will ever get in Queens and Richmond together, while the swamp lands alone, that would have been bought with the upland, could, on the basis of the Muddy River improvement of Boston, have been turned into one of the most magnificent parkways in the world.

Thus there has come and gone, within four years, the opportunity of acquiring such a park system, without the expenditure of a dollar, and yet it has been neglected for the very reason, so bluntly exprest by one of our boro presidents not many years ago. He was askt: "Why don't you do these things decently?" To which he replied: "What do I care for a thing that costs all that money, if it takes so long to do it that we can't get anything out of it before my term of office expires?" That is all he thought about, and that is the element we depend upon for all our improvements. That is why we have to go to the legislature for all of our greater works and our greater commissions. Yet this man was a good one at that, as practical politicians go, but he was elected for the purpose of representing his term of office and perhaps that of his successor, which might be himself.

Mr. Lamb's idea of applying this principle of extra land condemnation to the acquisition of the badly needed intermediate avenues between Fifth and Sixth and Sixth and Seventh Avenues is so practical as to be axiomatic. As he says, there is abundant successful precedent for it, and the only requisit is a brief act of our legislature.

His idea of keeping our streets undarkened by skyscrapers without limiting their hights, merely compelling them to follow the "angle of light" plan, is the first practical suggestion on that subject ever submitted to any of our engineering societies, and is so good that I wish this society could, by some resolution, or in some way, put itself on record as approving that scheme, not necessarily his particular design, but the scheme which limited the sky line and gave us walks and the passageways at various elevations.

Mr. Alberto Schreiner.—I have had occasion to visit some of the most important cities in Europe, South America and this country, and naturally, as an employee of this city, I have taken great interest in the beautifying of the City of New York.

It is true that we find a number of very beautiful cities in Europe, but at what cost were they beautified? We call Berlin a beautiful city as far as the general street layout, roads, streets and avenues, squares and parks are concerned, but was the City of Berlin as beautiful before the Franco-German war? It was not. It was only after the war and the resulting enormous increase of business that the people realized that the city had to be beautified, and it was accomplisht at an enormous cost and sacrifice.

The same pertains to the City of Paris, which before the Second Empire could by no means be called a beautiful city. It had its imposing monuments and edifices, but as a city it was not beautiful.

The same took place in the City of Vienna. Only during the last forty years were the beautiful parks, squares and boulevards projected and laid out so as to give a city that is not only practical and useful, but also beautiful.

In all these cities the change towards a practical, useful and beautiful general plan, with its consequent numerous details, was only accomplisht by subjecting the inhabitants to great inconvenience and to an enormous outlay of money.

Here in New York City it was entirely out of the question during the past to beautify it. The extraordinary rapid development and the peculiar conditions we had in this city, did not allow of beautifying the same, but at the same time there is no reason why, in laying out our parkways, boulevards and parks, we should not have considered the esthetic side. It seems to me that we, as engineers, are rather selfish. We are apt to lose sight of features which are necessary to adorn our work, not only as a benefit from the esthetic standpoint, but also as a benefit to our senses and pleasure of living.

Mr. Lamb brought up to-night some very interesting suggestions to beautify New York City, to be executed only at an enormous expense. I think those multiplications of certain street lines cannot be forced at once, principally with the temperament of our population. There are too many interests pressing all the time, and any sudden radical change would not be allowed. I see no reason, however, why we should not take care of certain details, and start in a small way to improve existing conditions. I can not see why we should have hydrants above our sidewalks; why not have iron covers level with the sidewalk and the hydrants underneath? Connections could be made just as readily; the existing hydrants certainly are a nuisance and an eyesore.

Why have on our corner lamp posts the kind of letter boxes Uncle Sam is so kind to furnish? If a prize competition for the most unsightly letter box had been arranged, the letter boxes we see on our street corners would certainly have won the first prize. As proper pendants in point of ugliness our fire alarm lamp posts rival successfully with the letter boxes. Gas and electric light companies erect lamp posts and wire poles without any regard to a pleasing appearance. We see wooden telegraf and telefone poles with a diameter ranging from 9 to 24 in., from 20 to 80 ft. in hight, vertical or inclined at any angle, cross-trees horizontal or not. It seems that in this matter special efforts are made to produce as ugly an appearance as possible. Wherever cast-iron wire poles are used they could be made of artistic design with only a very small increase in cost.

If such an inartistic picture impresses itself on our eyes looking upward, what do we see looking down? Curbstones from 3 to 8 in. in thickness, in all kinds of conditions, of bluestone, sandstone or concrete, in line or not, changing in appearance sometimes every 100 ft. Our sidewalks rival with the curbs, changing plane, grade and elevation from house to house and made of any material. These are conditions we do not only see in outlying streets or in the factory or tenement districts, but in some of our most important thorofares.

All these are conditions which, by the application of a little effort and good will, could readily be changed by the engineers. Improvements in small details will produce such an impression of neatness as to soften to a great extent other inartistic and harsh features of our city.

It may interest you to hear of instances where certain cities which were unhealthy, dirty, poorly laid out, etc., have been changed so as to rival in all respects some of the most beautiful cities in the world.

The central or business part of the city of Rio de Janeiro was, up to ten years ago, a conglomeration of narrow, ill-ventilated and poorly paved streets. The most important shopping street was only about 20 ft. wide. In the last few years a wide beautiful boulevard was cut straight thru the town, following a line not only most convenient for the general direction of traffic, but also parallel to the most prevailing winds coming into the harbor from the sea. Marginal boulevards were bilt following the shore, mosaic sidewalks were laid, shrubbery and trees planted, very artistic lamp posts erected and numerous other improvements carried out. From a repellent city it was changed into a town where pleasing and beautiful features meet one everywhere. While formerly it was a pesthole of yellow, malarial and tropical fevers, it now is one of the healthiest cities in the world. The increase in value in the properties abutting on the lines of improvements was such as to compensate for the outlay. Rio de Janeiro, formerly avoided even by Brazilians, now attracts nativs and foreners alike.

Buenos Ayres, the capital of the Argentine Republic, and without dout at present the most beautiful city on the American continent, has attained this position only thru the energy and intelligence shown by its engineers. Boulevards, parks, squares, lamp posts, telegraf poles, letter boxes, sidewalks, benches and all other features of public utility are designed and bilt to form a harmonious whole, following the most artistic precedents.

If all these things can be done elsewhere there is no reason why we should not be able to do them here. If we would apply our efforts towards attaining these results in a practical and steady way, while we may not enjoy those improvements during our lives, we can, however, by laying our selfishness aside, let our children receive the benefit of our foresight.

MR. CHAS. R. LAMB.—I have taken up so much time, Mr. President, that I can hardly answer the various gentlemen who have discust my paper. May I instead say that to my mind, the fundamental difficulty is a lack of imagination. No particular person or profession has a mortgage upon the imaginativ faculty. The great French engineer imagined a point 1 000 ft. above the Seine, and the Eifel Tower rose because he saw it first in his imagination. So, too, you engineers can develop your imagination, and you, too, can solve any problem offered, and when you so solve it, you will find you have been talking in terms of artistic beauty. The lines of the Eifel Tower are not straight ones, it is an artistic structure, one which if it is ever taken down the beautiful City of Paris will not be quite so beautiful.

I think Mr. Tillson was answered by Mr. Eliot. Time is not essential if it is true, as it is, that the changes in Paris were made under Napoleon III, changes which practically decided the great boulevards of Paris, and made that modern city, to which millions of dollars and millions of pounds sterling and of other moneys go annually, because it is so beautiful. This period is within our time. So Vienna, so London, and so each great metropolis, in turn, are spending and making their improvements right now in our day. Who has the imagination needed for our Greater City? Who had it in the past? The man who had more belief in what New York was going to be was that man who died in prison; he was a politician. You know his name—Bill Tweed.

Riverside Drive, all the parks of The Bronx, those improvements of which we are so proud, and to which the "Seeing New York" buses go driving and showing to the visitors, were believed in by him. Politician tho he was, dishonest man as he was, he still believed in his city. How many of you do the same thing? The extent to which you believe in your city and give evidence of it is by what you say and what you do individually or collectivly in groups as you are now; just that much you will help forward your city. Suppose this organization should do as the Art Societies did? Here among yourselves, without outside critics, make your own arguments, put them up on the screen and criticise them. For example, suppose you should say there ought to be an avenue between Fifth and Sixth Avenue, right straight thru the center of the 800-ft. measurement straight up to the Park. Draw it on a City map. Design an avenue 100 ft. wide, with lots facing the avenue east and west, and you will find you could secure this great improvement for nothing, provided your laws gave you the right to sell the property on either sides of the avenue. Prove the argument so that nobody can controvert it, and then say to the lawyers, "Gentlemen, why don't you change the law so that we can have such improvements." We don't need to wait a hundred years for improvements. If we have the legal right-of-way we can get them in the next five or ten.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 41.
PRESENTED MAY 27, 1908.

THE SEWERAGE PROBLEM OF THE BORO OF QUEENS.

BY MR. ALBERTO SCHREINER,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
DANIEL D. JACKSON, SIDNEY W. HOAG, JR., VICTOR H. REICHELT, MYRON H. LEWIS, AND THE AUTHOR.

With the rapid increase of population, industries and commerce in New York City, engineering problems of vast extent are appearing, requiring not only the highest skill in structural design, but also broad and far-reaching judgment in planning their solution.

For instance, it is not only necessary to design a bridge able to carry a certain amount of traffic with its resultant load, but also to plan schemes of handling, receiving and distributing such traffic at its approaches. The problems to be solved in planning subways, tunnels, etc., for transportation purposes are of such varied nature and far-reaching character as to appear insuperable. The question of collecting, storing, purifying and distributing water for the City of New York, is of such magnitude as to make us gasp with wonder, accustomed as we are to tremendous feats of engineering.

These and other problems of immense proportions and monetary outlay are continuously discust and described in the daily and technical press. There are, however, some engineering problems just as difficult to be solved, of which we hear very little. One of these, which the author will try to describe, is the sewerage problem of the Boro of Queens.

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* Assistant Engineer, Bureau of Sewers, Boro of Queens.

It is not local pride that makes the author state that the sewerage problem of the Boro of Queens is the most complex and extensiv that has been or is to be solved anywhere. To substantiate this statement he will endeavor to show the present and future conditions of the Boro of Queens.

Plate 44, Figs. 1 and 2, and Plate 45, Fig. 1, do not represent scenes on the canals of Venice, as may be noticed by the absence of gondolas and by the architecture of the houses. Plate 45, Fig. 2, shows a closely bilt-up area where the venerable and time-honored out-house is still in full power. The soil in this section is formed of a glacial deposit of sand, gravel and small boulders. It has been saturated to such an extent with sewage that in the full meaning of the word the inhabitants sleep on a mattress of fecal matter. These are conditions which can be found in almost any thickly populated village which is not provided with sewers. These different pictures were not taken in an undevelopt country, but within the limits of the greatest, richest and most prosperous city of the world. They were taken in the Boro of Queens, and the pollution of the soil which results from the great number of out-houses on such porous glacial drift is made doubly important when we consider that practically all of the water for the Boro of Queens is subsurface water.

Why do such conditions exist? Are there any plausible excuses? There are, but to understand the reason for such a state of affairs it is necessary to analyze the different factors which formed the causes of such effects.

Prior to consolidation, what is now called the Boro of Queens consisted of Long Iland City and the townships of Newtown, Flushing, Jamaica and a part of Hempstead, and each one of these townships was composed of scattered settlements and villages, such as Hunters Point, Blissville, Dutch Kills, Ravenswood, Astoria and Steinway in Long Iland City, Ridgewood, Melvina, Woodside, Newtown, Corona, Middle Village, Maspeth, Laurel Hill and Glendale in the township of Newtown, Flushing, College Point, Whitestone and Bayside in the township of Flushing, Jamaica, Wood-

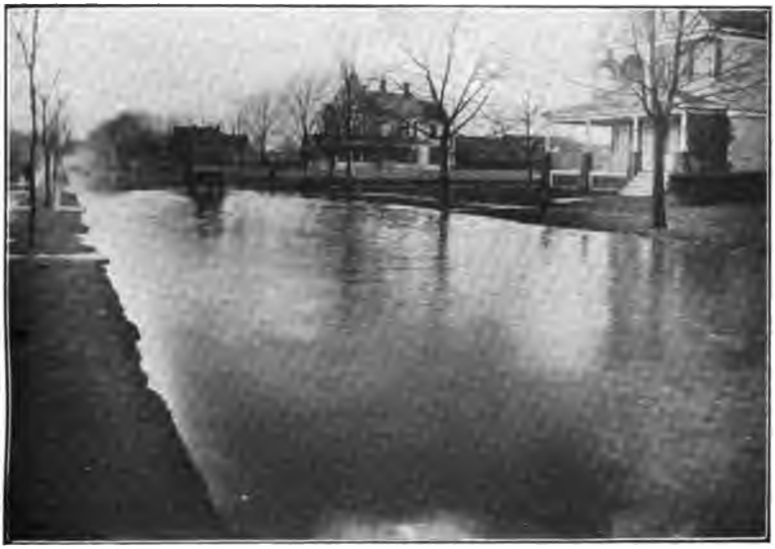


FIG. 1.—LEFFERTS AND STEWART AVENUES, RICHMOND HILL, FEBRUARY, 1908.

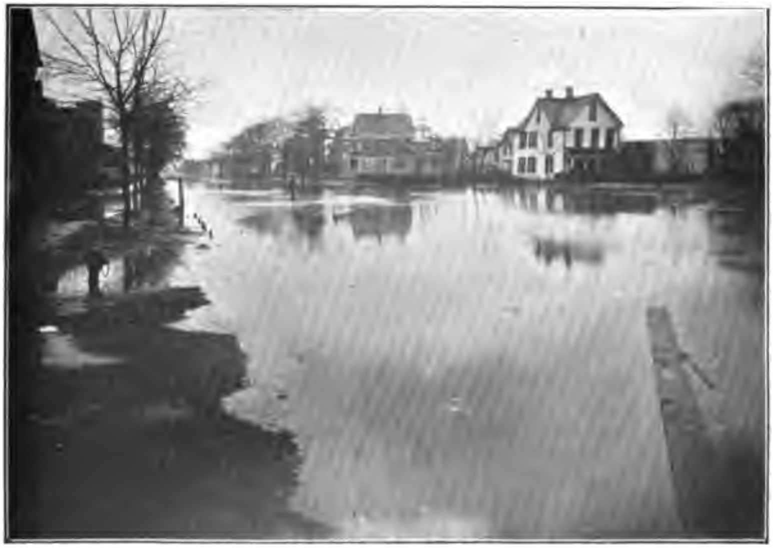


FIG. 2.—GREENWOOD AND LEXINGTON AVENUES, RICHMOND HILL, FEBRUARY, 1908.

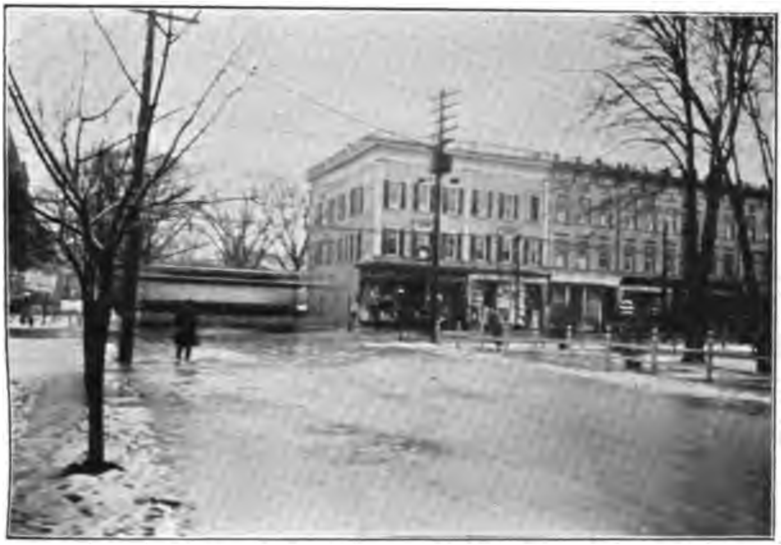


FIG. 1.—BUSINESS SECTION OF RICHMOND HILL, JAMAICA AVENUE AND ELM STREET.

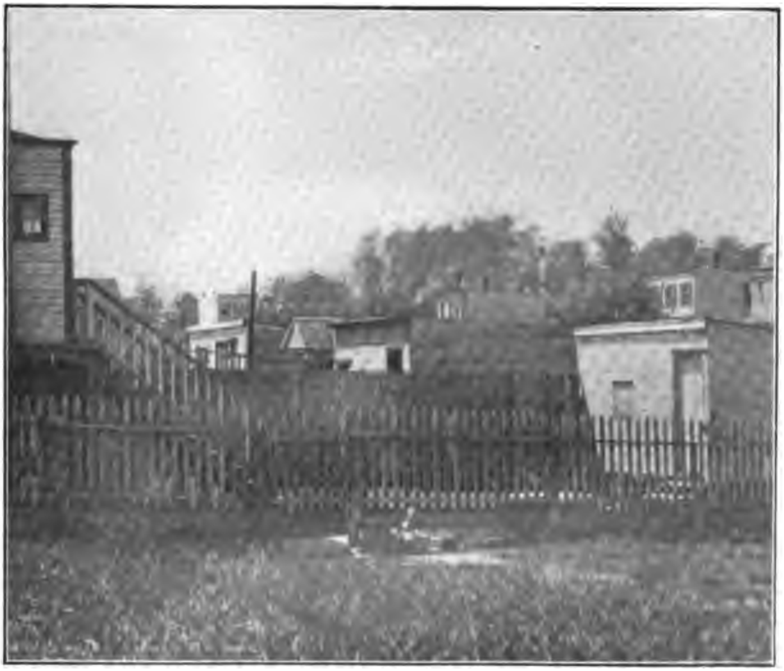


FIG. 2.—OUTHOUSES IN WOODSIDE, SECOND WARD.

haven, Queens, Richmond Hill, Hollis and Springfield in the township of Jamaica, and Rockaway Park, Arverne, Edgemere and Far Rockaway in the township of Hempstead. With the incorporation of these townships into Greater New York City, their old names were abolisht, and changed into five numbered Wards composing what is now the Boro of Queens.

In what condition, from the point of view of the municipal engineer, were the street systems, maps and plans of these different sections of the Boro of Queens, when consolidation took place?

The First Ward, formerly Long Iland City, had been surveyed in 1872 by the Long Iland City Improvement Commission, a street system and grades establisht, and a system of monuments set, where necessary and convenient.

Of the Second Ward, formerly the Town of Newtown, "silence" would be the proper description of any street layout, grades, etc.

In the Third Ward or Town of Flushing, very inefficient maps existed of the villages of Flushing, Whitestone and College Point. These maps are of little value for engineering purposes.

Of the whole Fourth Ward or township of Jamaica only a contour and grade map of the village of Jamaica was in existence.

The Fifth Ward, the Rockaways, was in the same condition as the Second Ward.

According to the charter of the Greater City, no street improvements, such as sewers, paving, curbing, grading, etc., could be authorized without officially approved and adopted street system, grade and drainage maps. Actual construction could not begin without the city acquiring title to the respectiv highways. Thus the different steps of condemnation procedings were vestment of titles, opening procedings, surveys and maps for opening procedings and surveys for and the preparation of damage maps. That is, a territory of about 75 000 acres, or 118 sq. miles, which had to be surveyed and laid out as part of the big city, a work involving an enormous amount of labor and monetary outlay.

Under the first charter of the Greater City all topographical work was done under the Board of Public Improvements. The work done in this line in the Boro of Queens during these four years was of practically no importance, owing to the small force employed. With the amendment of the charter taking effect in the beginning of 1902, the topographical work was placed under the President of the Boro. The following table shows, better than anything else, the history of the work done by the topographical bureau in the Boro of Queens:

Total area of Boro of Queens	75 111	acres
Area of street system adopted	27 380	"
Area of final maps adopted	11 350	"
Area topographically surveyed	58 000	"

Expenditures of the Topographical Bureau.

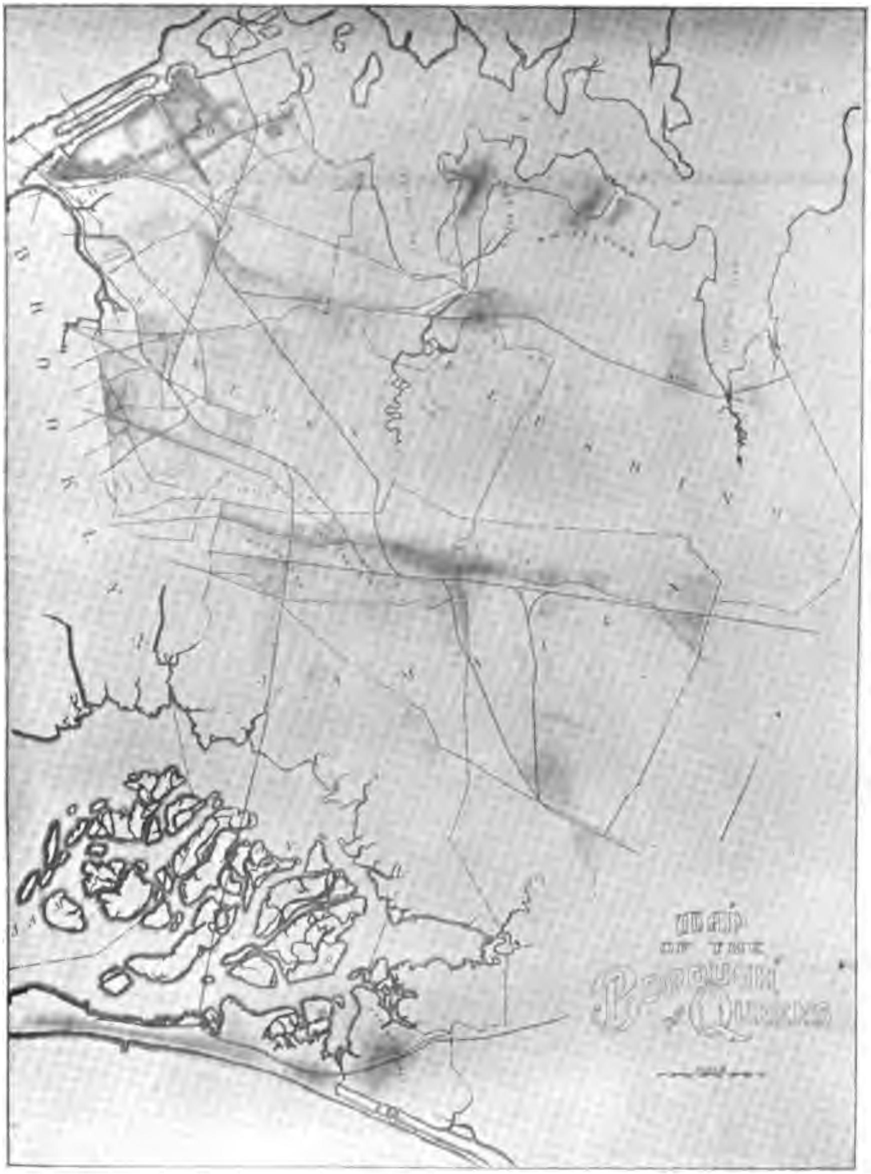
1898-1901	$90 000.00	1905	$210 278.50
1902	35 901.00	1906	261 612.98
1903	63 500.00	1907	277 998.39
1904	165 817.56	1908	322 000.00

The force employed in 1902 was about 25 men, since which time it has been gradually increast, until at the present time the number of men employed is about two hundred and thirty-five.

The following table shows by wards, the area of the Boro of Queens:

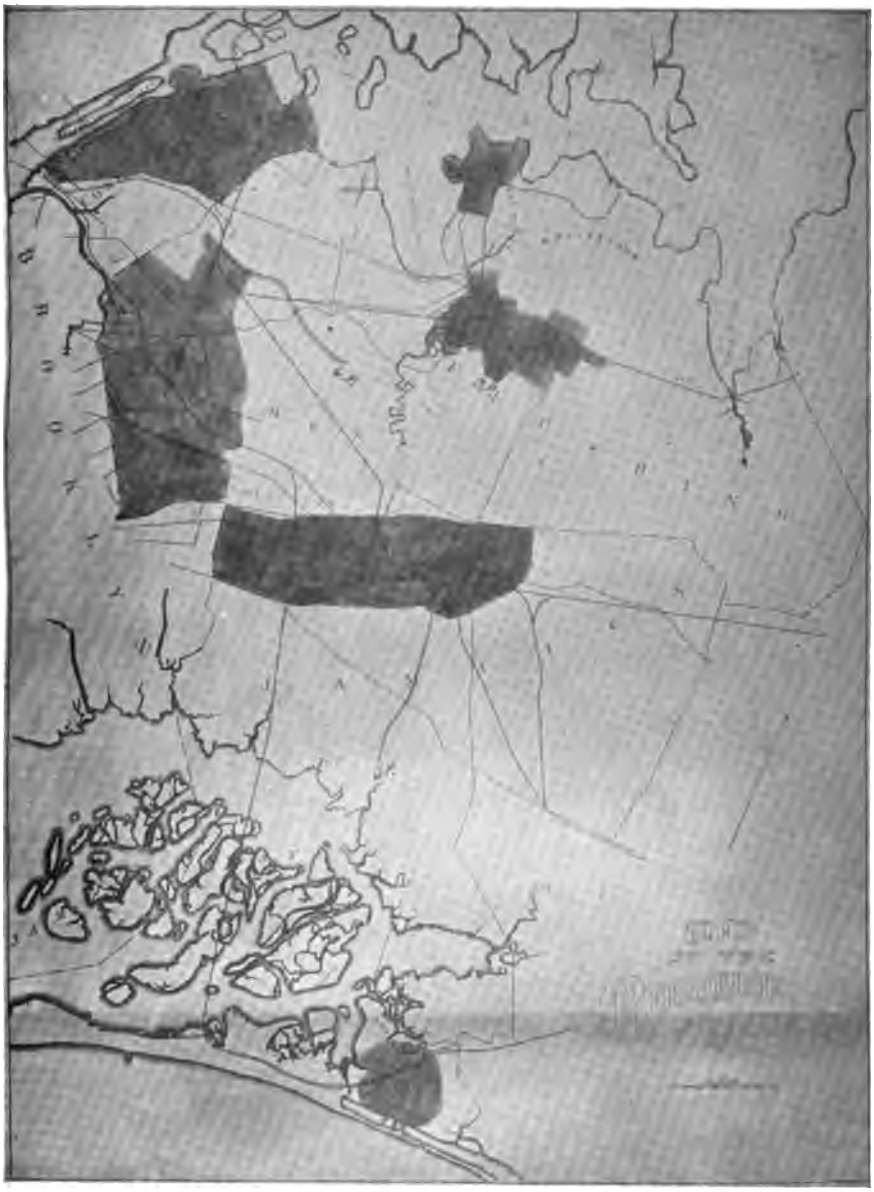
Wards.	Description.	Acres.	Acres.
1st.	Land to bulkhead line		4 740.6
2d.	Land to mean high water	13 968.7	
	Land under water to bulkhead line	116.0	
	Total		14 084.7
3d.	Land to mean high water	19 209.2	
	U. S. Army Reservation, Willets Point	146.0	
	Land under water to bulkhead line	149.0	
	Total		19 504.2
4th.	Main land to mean high water	22 849.9	
	Ilands in Jamaica Bay, mean high water	2 339.3	
	Lands under water, mean high water	5 610.8	
	Total		30 800.0
5th.	Land to mean high water	3 920.7	
	Land under water	2 060.7	
	Total		5 981.4
	Grand total		75 111.0
	Total land (dry)		67 174.4
	Total land under water		7 936.5

PLATE 46.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.



Map of the Boro of Queens, Showing the Distribution and Density of the Population.

PLATE 47.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.



Map of Boro of Queens, Showing Existing Sewerage Systems.

As already mentioned, the Boro of Queens is composed of a number of small towns, villages and settlements scattered here and there, whose density of population varies widely. Plate 46 shows by means of differently shaded areas how the population of the Boro of Queens is distributed. We may say that improvements planned for this boro will not be improvements for a city but for a whole country, with the fact in view, that the different towns and cities situated in this country, will some day form an enormous metropolis. In Plate 47, the shaded areas indicate the sections for which drainage maps have been prepared and adopted. The heavy lines show the territories which have been sewered or in which trunk sewers have been bilt or are under construction.

In the First Ward of this boro, formerly Long Iland City, a number of distinct drainage districts are to be found. Some are almost fully developt, while some contain only a main trunk sewer and a few laterals. The sewerage system of Hunters Point was bilt under the "First Ward Improvement Commission" in 1876, and some of the outlet sewers will have to be reconstructed in the near future on account of insufficient capacity. Adjoining this system and north of it we find the Harris Avenue trunk sewer, 7 ft. 8 in. by 7 ft. 7 in., bilt about twelve years ago, over half of its drainage system still being undevelopt. The next drainage area is drained by the Webster Avenue trunk sewer. In its construction many difficulties were encountered. To obtain the desired capacity of a 14-ft. circular sewer, conditions demanded that for the first half of its length it should have a twin horseshoe section. It then changes to a single horseshoe section equivalent to a 9-foot sewer (the capacity of all sewers is here exprest in terms of the diameter of an equivalent circular sewer). The lower third of this sewer was bilt thru the only rock outcrop on Long Iland. The middle third crosses a swamp on heavy pile and timber foundation, many of the piles being 45 ft. long. The remaining third was thru a sand hill, necessitating a trench 45 ft. deep and 30 ft. wide at the top. This sewer was completed in 1903, and a number of its laterals have been bilt.

North of this district the Broadway system is found, with a 16 ft. by 7 ft. trunk sewer. This system is nearly completed, but the trunk sewer near its outlet, bilt in 1896, is in bad condition and will have to be reconstructed in the near future.

Continuing in a northerly direction we find the 8 ft. by 12 ft. Hoyt Avenue sewer discharging at Pot Cove near Hell Gate. The system of which this sewer is the trunk is nearly completed. North of this section no sewers forming part of a comprehensiv system are in existence, and only lately has one been designed with an 11 ft. 6 in. trunk sewer discharging at the bulkhead line, the dry weather flow to be cut off and carried by means of a 3 ft. 6 in. sewer to the pierhead line, about 1 400 ft. distant.

For the Blissville section, situated at the southeasterly end of Long Iland City, a pumping station has to be provided to pump the dry weather flow under Dutch Kills Creek to the East River, as the discharge of crude sewage into either Dutch Kills Creek or Newtown Creek is not permitted.

In the Second Ward, formerly the town of Newtown, few sewers have been bilt. Very complex problems of disposal are here found. One of the trunk sewers is of circular reinforced concrete 15 ft. in diameter, and discharges into a 16-ft. sewer in the Boro of Brooklyn, which in turn discharges at the head of Newtown Creek. This same outlet sewer receives the dry weather flow of two separate sections, having a combined area of 4 500 acres, which has to be pumpt into a gravity sewer discharging into the East River.

Another sewer, designed and authorized by the former Board of Public Improvements, runs for a considerable distance as a pipe sewer, along a ridge, thru Woodside Avenue, attaining a depth of 45 ft., and continuing as a brick sewer thru Broadway and Hoffman Boulevard to the Elmhurst Disposal Plant. (See Plate 48, Fig. 1.) This plant is composed of a series of sedimentation tanks and sand filters (see Plate 48, Fig. 2). Its location was establisht in entire disregard of the topography of the drainage area, and in a few years the effluent will have to be pumpt into some gravity sewer and be discharged into Flushing Bay.

The remaining section of this ward presents the most difficult problem of disposal of the whole boro. Pumping stations and disposal plants will be required for the entire section, which has an area nearly as large as Manhattan Iland. The location of these stations and disposal plants is a matter requiring very careful and extensiv study, and its importance from a monetary point of view is comparable with the location of a rapid transit route.

PLATE 48.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.

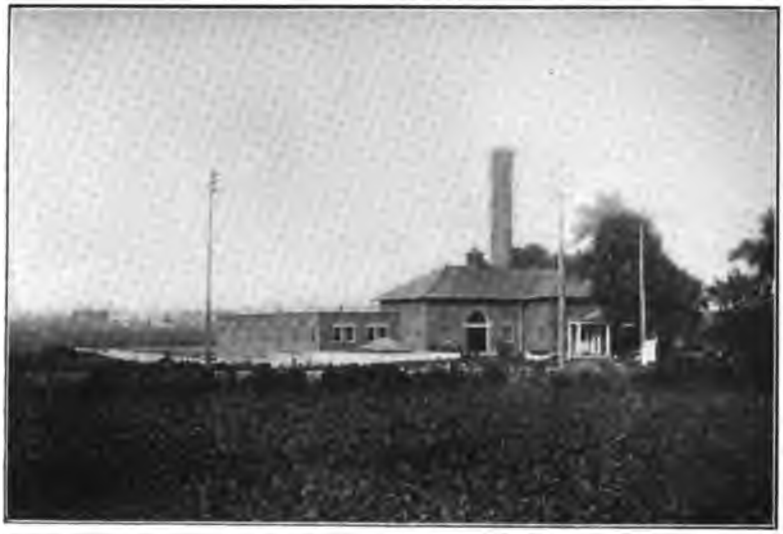


FIG. 1.—ELMHURST DISPOSAL PLANT.

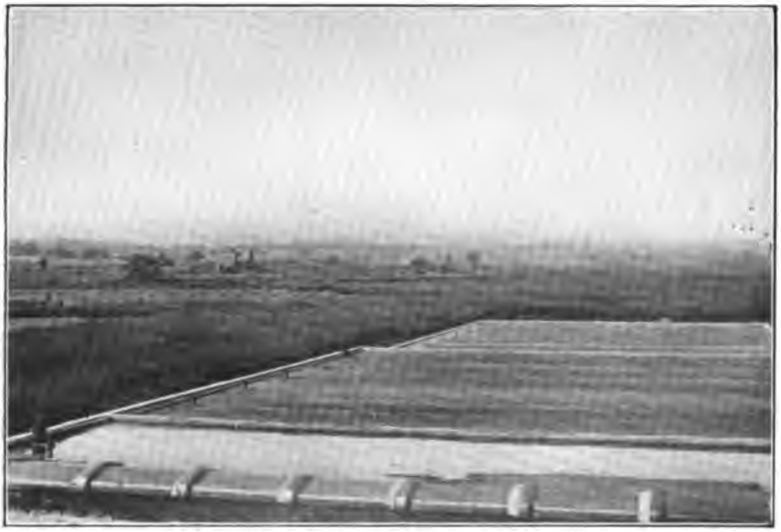


FIG. 2.—FILTER BEDS OF ELMHURST DISPOSAL PLANT

In the Third Ward, formerly the town of Flushing, a very inadequate system of sewers is to be found in a section of the village. A number of the sewers require immediate rebilding. In the so-called Ingleside section, covering about 1 200 acres, a 9-ft. 6-in. sewer (Plate 49) and some of the main laterals are under construction. The dry weather flow of this area is to be cut off from this trunk, and treated in a disposal plant now being designed. This disposal plant will consist of a screening well, grit chambers, sedimentation tanks, sprinkling filters and final settling tanks.

In the village of College Point a well-working combined system of sewers exists. On account of the discharge of some of the smaller sewers on flats exposed at low tide, producing insufferable conditions, some new sewers were bilt, diverting the sewage to a new outlet, which in the near future will be carried to deep water. On the East River side of College Point, a 2-ft. 6-in. wooden barrel sewer 1 100 ft. long was bilt and lowered to the bottom of the East River, its outlet being about 16 ft. below mean water.

In Whitestone and Bayside some small sewers were bilt before consolidation, and the manhole heads of a number of these sewers were carefully buried when the roads were graded and improved, and as no records or plans of such sewers are in possession of the Bureau of Sewers, the true extent of these systems is somewhat enigmatical.

In the Fourth Ward, formerly the town of Jamaica, a separate system of sewers is in use, covering about 10% of the whole area. The effluent from these is treated in a chemical precipitation plant (Plate 50) which will be changed before long so as to secure a more modern and efficient treatment. A system of sanitary sewers has been designed for the Richmond Hill section of this ward, and a 10 000 000 gal. disposal plant will be required to treat the sewage collected from this area.

In the Fifth Ward, commonly called The Rockaways, is a separate system of sewers. In Far Rockaway the sewage is lifted by ejectors into a chemical disposal plant, which also is antiquated and inefficient. The remainder of the ward presents a very difficult but interesting problem. The mean elevation of the ground is only five or six ft. above mean high water, calling for a very extensiv lifting system. The winter population is about 10 000, but the summer about 150 000, the territory being almost completely given over to summer resorts. It fronts upon Jamaica Bay and the ocean, but no sewage can be discharged into either, consequently a disposal plant must be designed which will be economical and effectiv, when working at either the maximum or minimum flow.

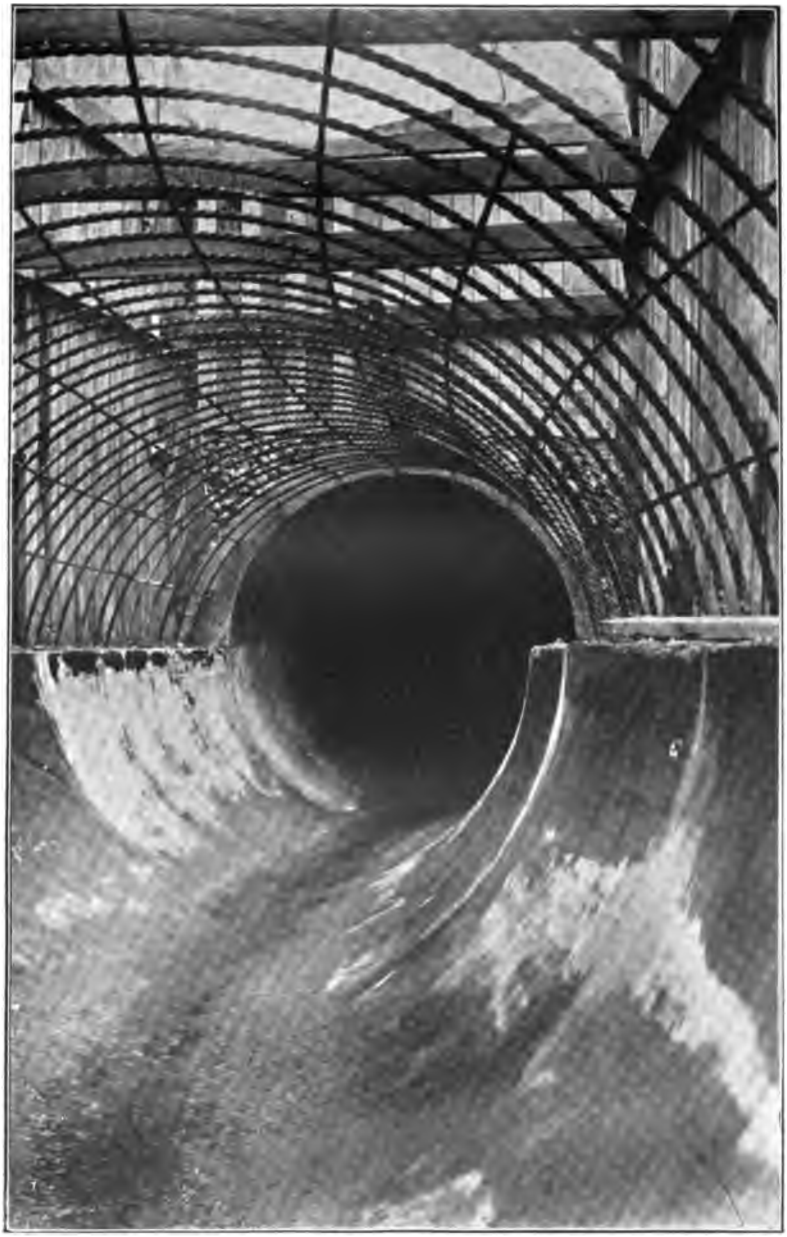
Wherever separate systems are used or contemplated in this boro, the storm sewers must extend thru the entire length of each block to take care of the roof water, as otherwise the cost of pumping would reach enormous figures. The effect of this will be to more than double the cost of sewering the largest part of this boro.

In this connection it may be mentioned that the matter of locating the various disposal plants needed in the near future in the boro is of great importance. The fixt charges and cost of maintenance of these plans will reach enormous figures, and it is obvious that a point will be reacht where the cost of construction and of maintenance of these plants would exceed that of a possible substitute, even tho of very expensiv construction, designed to carry the sewage of the Boro of Queens to some outlying part of the shore along the ocean front, where it could be discharged without creating a nuisance either in connection with bathing or by reaching the waters of New York Harbor.

It is natural that in discussing any engineering work in any one of the boros of the City of New York, we would like to know the relativ importance of such boro with respect to the others. Plate 51, Fig. 1, shows the relativ position of the Boro of Queens and the other boros as to area, population, density of population, and the population it could accommodate if the density of population were equal to that of the other boros.

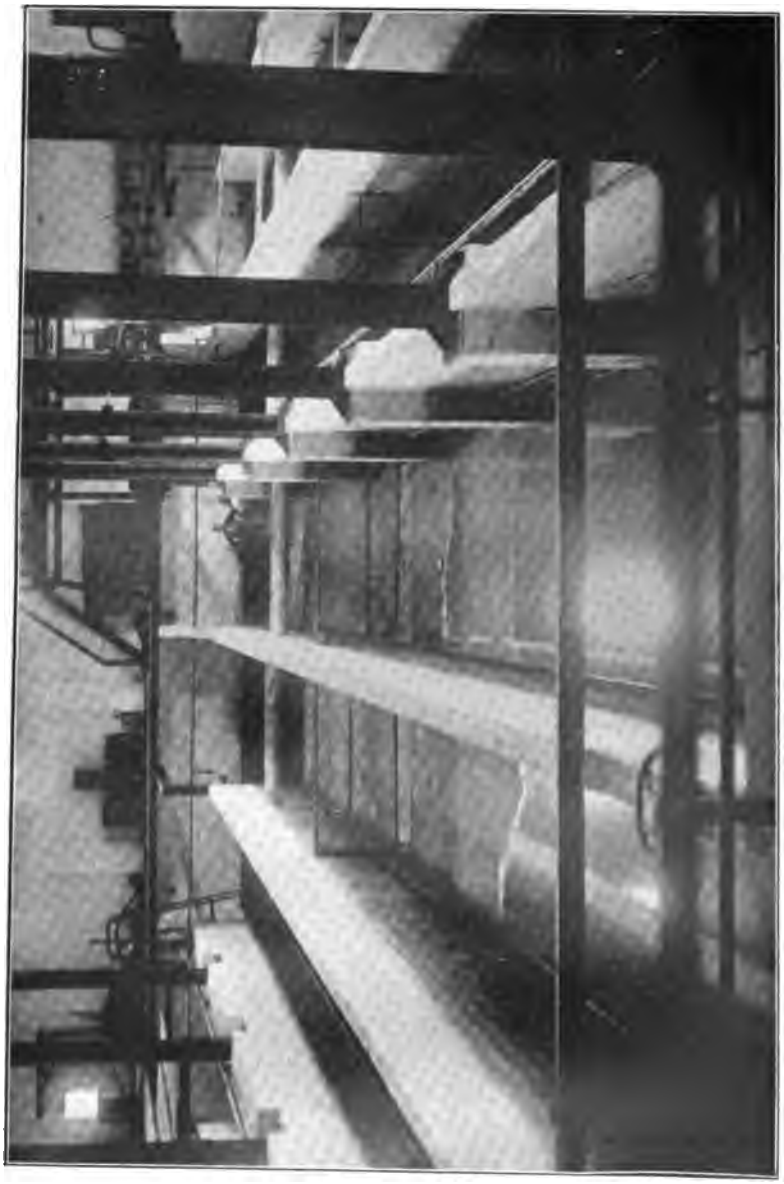
Is the sewerage problem in the Boro of Queens more difficult of solution than that of the other boros? The diagrams shown on Plate 51, Fig. 2, indicate that the Boro of Queens has the least available waterfront of all the boros. That is, the least waterfront available to discharge crude sewage. Owing to state laws, it is not allowed to discharge crude sewage into Newtown Creek, Flushing Bay or Jamaica Bay. Little Neck Bay is so shallow that to discharge sewage into the same would be the formation of a gigantic cesspool. The ocean front along the Rockaways is, for obvious reasons, entirely out of the question as far as its use for sewer outlets is concerned. The result is, that we have only the

PLATE 49.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.



Ingleside Trunk Sewer.

PLATE 50.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.



Jamaica Disposal Plant.

East River, from Newtown Creek to Flushing Bay, and from Flushing Bay to Little Neck Bay available for the discharge of crude sewage.

On account of the limited frontage into which sewers may discharge, there arises the problems of locating disposal plants, pumping stations, intercepting sewers and main outlets so as to be as economical as possible in both construction and maintenance costs, in addition to the problems of the extent and size of such structures.

Will the Boro of Queens be in the near future of such importance in population, wealth, commerce and industries as to warrant the design of such expensiv structures? To answer this question it is necessary to study the possibilities of the boro.

Improved transit facilities have always proven to give a great impulse to the increase of population, and we find that in the Boro of Queens such increase will take place in the near future. The different lines of the New York Queens County R. R. Co. extending to Astoria, Steinway, Elmhurst, Dutch Kills, Blissville, Maspeth, Middle Village, Corona, Woodside, Flushing, College Point and Jamaica, will shortly reach Manhattan by means of the Belmont tunnels and the Blackwells Iland Bridge. Due to the opening of these new connecting links, the lines of the above-mentioned company will be extended to Whitestone, and a new line will be bilt following practically a direct route from the Blackwells Iland Bridge to Jamaica.

The Myrtle Avenue elevated line of the Brooklyn Rapid Transit Co., running from Metropolitan Avenue in Queens thru Brooklyn and over the Williamsburg Bridge to Manhattan, will be a great factor in developing the Ridgewood and Middle Village section of the Second Ward. The completion of the Pennsylvania R. R. tunnels, and the electrification of the Long Iland R. R. lines, will give a rapid and commodious means of transportation from the most important points of the Boro of Queens, either to the Pennsylvania R. R. station at Seventh Avenue and Thirty-second Street in Manhattan, or to the business districts of. Brooklyn and Manhattan, connecting with the existing subway.

A fact that has helpt to retard to a great extent this increase, has been the delay in opening the Belmont Tunnel, and the Blackwells Iland Bridge, as the opening of the McAdoo tunnels to New Jersey has undoutedly diverted a great amount of population and capital from Long Iland.

Due to the numerous improvements in transportation to New Jersey and the territory lying north of New York City, improvements of any kind in the Boro of Queens have to be carried out with the utmost expediency to meet the increasing competition.

Plate 52, Fig. 1, shows the bilding operations that have taken place in the Boro of Queens since 1898. It is interesting to note that from 1904, when the different projects of improved transit facilities began to materialize, the increase of bilding operations was very markt indeed. This diagram also shows the effect due to the financial depression of 1907.

Plate 52, Fig. 2, shows graphically the past growth of the boro in population, in traffic carried by the passenger lines, in the erection of bildings, and in assest valuation. Each of these is in a sense a measure of present and anticipated growth, and each should also be considered in determining the amount of improvements which the city is warranted in carrying out. The projections of the four lines into the future were made by drawing lines representing the average of past rates. The heavy line represents the mean of these four, and is used in approximating future population.

The most important factors which have to be considered in designing the different drainage systems of the boro, and which require close study and careful analysis are the following:

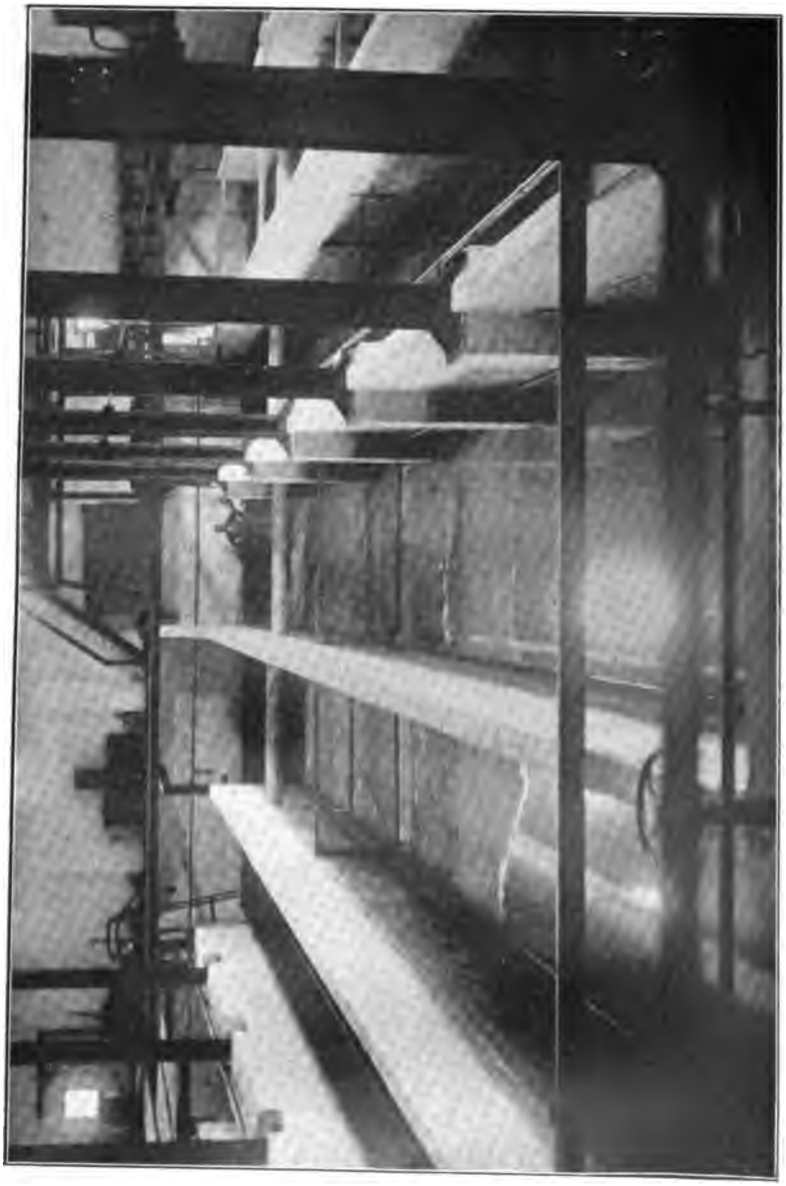
In which districts and under what conditions is a combined or a separate system of sewers to be used?

Shall the same percentage of run-off of storm water be used for the whole boro, or shall a different run-off coefficient be used for different districts, according to their probable future development?

Wherever disposal plants are to be constructed, shall their efficiency in regard to purification and clarification reach the same standard as that of plants discharging into waters that are to be used for drinking purposes?

In the near future shall an unlimited amount of sewage be discharged into the East River, or shall it ultimately be purified?

PLATE 50.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.



Jamaica Disposal Plant.

PLATE 52.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
SCHREINER ON THE SEWERAGE PROBLEM
OF THE BORO OF QUEENS.

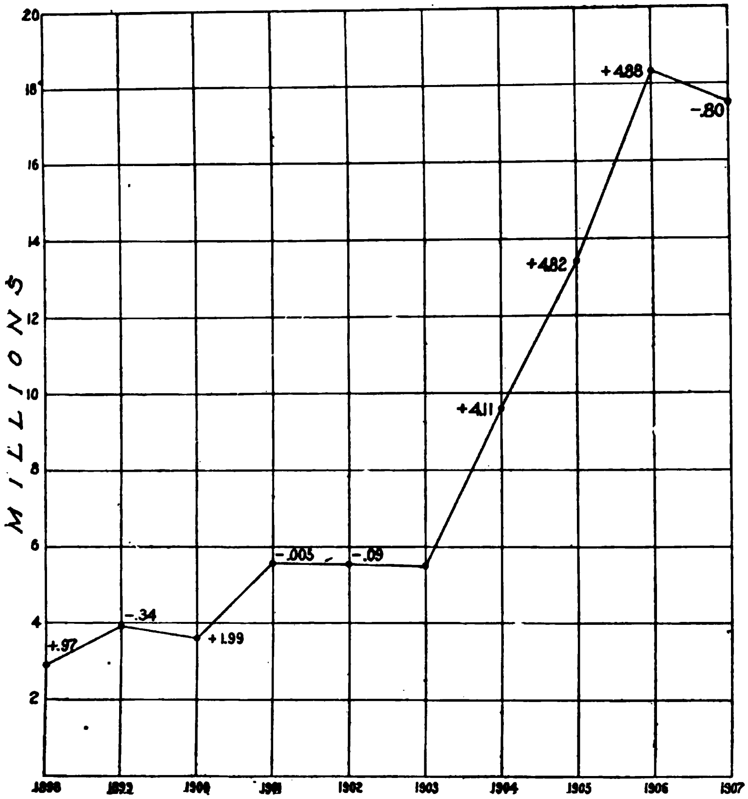


FIG. 1.—BILDING OPERATIONS IN THE BORO OF QUEENS.

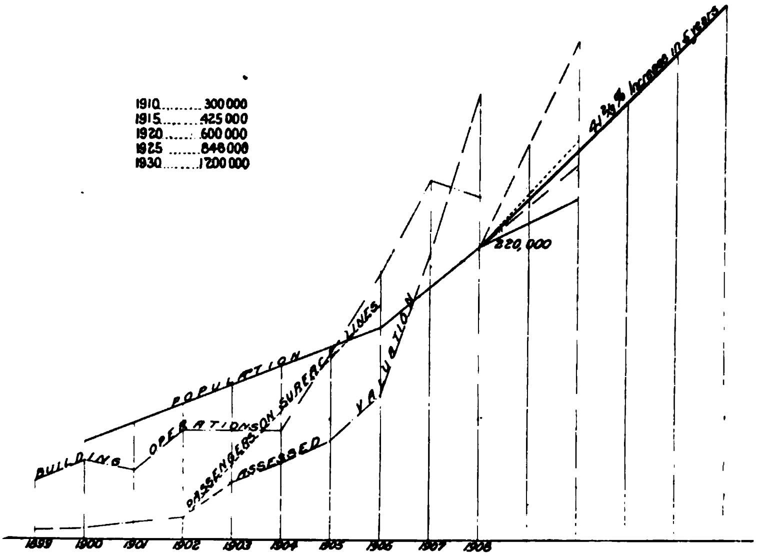


FIG. 2.—DIAGRAM SHOWING PROBABLE INCREASE IN POPULATION.

Would an enforced purification of manufacturing wastes, before entering the sewers, improve the general conditions of the sewage, so as to allow the discharge of the same into the East River, and allowing such purification and clarification by dilution as would not be reacht if manufacturing waste were present?

Would it not be more economical to construct large and expensiv sewers to such points where a strong current would cause dilution to an extent such as to preclude any previous treatment?

Besides these different points, it has to be considered, that, in territory of such character as in Queens, in spite of the rapid development of some sections, there are others, the value of which will not increase very rapidly in the near future, and that consequently heavy assessments for improvements should not be thrown upon them.

To make a comprehensiv study of all these conditions and to be able to work out a general scheme covering the collection and disposal of sewage in the Boro of Queens, it would be necessary that the authorities of the boro should have at their command a sum of money sufficient to meet the expenditures necessary to carry out such plans.

Finally, the insufficient size of sewers and the use of chemical precipitation plants does not reflect on the ability of preceding engineers. What would afford satisfactory drainage for an unpaved village street is no longer sufficient when the construction of paved city streets is considered imminent. Progress in scientific knowledge of sewage purification does not necessarily signify that previously constructed plants were not then properly designed. The present engineers can form some idea of the urban future of this area and must design and bild accordingly, if the necessary means to do so are placed in their hands.

DISCUSSION.

Mr. Daniel D. Jackson.—I have been very much interested in what Mr. Schreiner has said in regard to the disposal of sewage at high-water mark. The conditions which exist in Queens also exist in the other four boros. In fact, in many places, the sewage is discharged at points above high-water mark, runs on the surface of the ground and forms deposits, all of which are not washt away by the salt water. These deposits attract flies in the summer season as do other fecal deposits along the water front and the transmission of typhoid and other intestinal diseases is largely brought about in this way. The City of London has less than two-thirds the death rate of the City of New York from intestinal diseases of children. It has only about one-third the death rate from typhoid fever. In cities with protected water supplies these two diseases are transmitted largely by flies, and almost wholly during the fly season. The question of the proper disposal of sewage is second only in importance to the question of a proper water supply. It has nearly as much bearing upon the health of the community.

The method of disposal depends entirely upon the conditions. Mr. Schreiner spoke of factory waste. I spent considerable time as bacteriologist for the City of Worcester, where the question of factory wastes was a very important one. The Iron Wire Works there dispose of a tremendous amount of sulfuric acid and iron into the sewers, and this with the storm water dilution made it a matter of great difficulty to treat the sewage at the disposal plant. The problem was made easier by bilding a separate system of disposal for the storm water, and wherever the territory is large in proportion to the population, a separate system of sewers is most practicable. That allows for the treatment of a much smaller amount of sewage.

The question of sewage disposal at the present time is a matter which is only half solved, and in our city will probably be workt out along the lines of the removal of the suspended matters, for it is the suspended material which to us is the most dangerous. That which is in liquid form is quickly disposed of; that which is in solid form is liable to float ashore and fester on the banks and become the breeding place for flies, or, at least, these insects walk over the deposits and carry the disease back to the restaurants and to the food in our homes. The best means of disposing of solid matters is by septic tanks. The greater portion of the solid matter is liquefied by this means and from there on the further treatment with sprinkling filters or otherwise depends upon the necessities of the case. In places like Manhattan, where we have a dense population close to the sewer outlets, the sewage from the very large numbers of people comes direct to the water front without much disintegration, and it is very easy to see the conditions which are existing along our water front by an inspection. It is probable that some means of disposal of the nature of which I have spoken will have to be taken up in most of the boros, as well as in the Boro of Queens. At many points in Queens, septic tanks and sprinkling filters should be used.

MR. S. WILLETT HOAG, JR.—This seems to be a timely paper on a very important subject, and it appears to have been prepared at a time when this important question is ripe for discussion. The Boro of Queens is certainly facing a serious problem in the matter of sewage disposal, that is, in dollars and cents, and the solution of the problem owing to its serious nature must necessarily involve a large expenditure of money in some way or other.

Now, I am perfectly ignorant of the topographical conditions in the Boro of Queens, and do not feel competent to discuss this particular question. The very best way to dispose of sewage, when it can be done, is, of course, by way of a tidal waterfront. Special legislation would be necessary in order to carry out what I beg to suggest as a heroic treatment of this problem. I am simply leading up to a question which I would like to ask the writer of this paper, namely, has the scheme of constructing a waterfront to serve as an aid in disposing of this sewage been considered at all, in the nature of a study, such as would be afforded by a tidal canal from the upper East River to the Atlantic Ocean? The success of such a proposition depends upon the topographical conditions, and its execution would involve great expense. But under the circumstances any successful scheme for sewage disposal measured by a term of years is going to be found an expensiv proposition, and a tidal canal wide enough to provide a desirable short-cut between the Sound and Jamaica Bay, and affording revenue producing wharfage, would probably dispose of the question of maintenance of sewage disposal plants, and prove to be a very wise bit of foresight in the long run.

MR. SCHREINER.—A few years ago the Board of Public Improvements workt out a plan for a canal joining Newtown Creek with Flushing Bay, and, if I remember rightly, the difference in the tides between Newtown Creek and Flushing Bay would give a pretty fair velocity in that canal.

The question of joining the East River with Jamaica Bay I have heard discust at different times, but nothing definit has been done along that line, and even if our authorities were willing to take up such a project or study, they would have no means to accomplish anything.

MR. VICTOR H. REICHELT.—The author of this paper has mentioned that he does not think it justifiable to go to the expense of bilding large sewers in districts now thinly settled, of such size which would provide for drainage of storm water under conditions of an entirely bilt up district. Considering that such districts will not, for a very long time and may perhaps never, be entirely bilt up, I agree with him. I am connected with the Sewer Division in the Boro of Richmond, and have similar problems to deal with. As the expense of bilding sewers, in thinly settled districts, large enough for conditions of an entirely bilt up area would be ruinous to those districts, we have considered the possible development of the district within the next fifty years.

I would like to ask the author of the paper what period of years he considers in the designing of the sewers in the Boro of Queens?

MR. SCHREINER.—I can give you a few instances. The reinforced concrete sewer in Myrtle and St. Nicholas Avenues was designed of a very large capacity, able to take care of its whole drainage area at its maximum run-off. This territory is developing very rapidly and bilding up very closely. There are large numbers of tenements, asphalted streets, numerous means of transportation, etc. This sewer is big enough to take care of any development that will occur under any conditions. There are other sections, however, which will not develop so rapidly, which may possibly only begin to develop at a very rapid rate in ten or fifteen years. Naturally if we can give those people relief, with regard to sewers, for the next fifteen years by bilding a 3-ft. sewer, it would be unwise to bild a 15-ft. sewer.

MR. MYRON H. LEWIS.—I would like to ask Mr. Schreiner if he made any studies relativ to the question of leakage of ground water into the sewers of the separate system; that is, whether the disposal plants will be hurt by the infiltration of ground water? Mr. Hammond, of the Sewer Bureau of Brooklyn, gave me some very interesting figures on that subject some months ago, and I thought Mr. Schreiner might have something to say about it.

MR. SCHREINER.—We have not made investigations or studies in that direction. Up to about three years ago the whole engineering force of the Bureau of Sewers in the Boro of Queens was composed of five or six men. That included chief and assistant engineers, draughtsman and rodman, and with that force it was necessary to prepare plans, reports and estimates and take care of construction. Under those conditions we were not able to make any special investigations or studies.

BENCH LEVELS AND NEW YORK CITY DATUMS.

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THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 42.

PRESENTED SEPTEMBER 23, 1908.

BENCH LEVELS AND NEW YORK CITY DATUMS.

BY MR. CHARLES GOODMAN,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
ROBERT RIDGWAY, L. WHITE, ARTHUR S. TUTTLE, A. G. CULVER,
EDWARD S. HOLDEN, GEORGE A. TABER, HENRY W. VOGEL,
ROBERT A. WIMMER, GEORGE W. TUTTLE, ALFRED
D. FLINN, ROBERT R. CROWELL, WM. G.
FORD, HERMANN K. ENDEMANN,
CHARLES A. SULLIVAN, AND
THE AUTHOR.

This paper records the completion of 1 300 miles of bench levelling done by direction of Mr. J. Waldo Smith, Chief Engineer, Board of Water Supply, and which resulted in a continuous level line along the Board of Water Supply activities from Schoharie County south thru New York City and east thru Suffolk County, Long Iland. The levelling was based on the U. S. Coast and Geodetic Survey precise level line (datum mean sea level Sandy Hook), which starting at Sandy Hook past thru New York, and north along the east shore of the Hudson River. The accuracy of the work generally came within $C = .02$ in equation $E = C\ K$ where $E =$ error of closure, $C = a$ constant and $K =$ the distance in miles along level lines composing the circuit. The distance between bench marks varied from ¼-mile intervals along the aqueduct line to 1-mile intervals in New York and Long Iland.

---

*Assistant Engineer, Board of Water Supply, New York City, N. Y.

NOTE:—Mr. Alfred D. Flinn, Department Engineer of the Board of Water Supply, requested the author to present this paper before the Society, as it was thought that the large amount of data compiled during the levelling in New York City would be of interest to all City Departments.

Varying methods were used during the progress of the work, about 325 miles being run with target-rod methods, and about 975 miles with a 3-wire level and self-reading rods; the speed varied from 1½ miles in rough country to 13 miles on railroad work per 6 to 8-hour workday.

Checks on existing bench levelling of various organizations were had, especially in the vicinity of Greater New York, where an endeavor was made to continue the work of the Datum Planes Committee of The Municipal Engineers by establishing permanent bench marks in the public parks, and by touching the bench marks of all city departments in every boro. The tide gagings originating the various datums and the relation of datums is part of this paper, which ends with conclusions of accuracy, methods and levelling equipment.

The entire work is divided into five geographical departments. The Reservoir Department includes Ashokan reservoir and northward, the Northern Aqueduct Department, from Ashokan reservoir to Hunter's Brook (about 6 miles from Peekskill), the Southern Aqueduct, from Hunter's Brook to Yonkers, the Headquarters Department, covering Greater New York, and the Long Iland Department, from New York City to the east end of Long Iland.

THE DATUM.

The Primary Level Lines.

The U. S. Coast and Geodetic Survey level lines from Sandy Hook thru New York and north along the Hudson River, are the primary level lines of the survey. The primary bench marks used are shown on Plate 65. The datum for these lines is mean sea level, Sandy Hook, found from tide gagings. A type of tide gage apparatus is shown and described on Plate 63.

The precise level line was started in 1881, past thru Red Bank, Perth Amboy and then westerly approximately along the thirty-ninth parallel of latitude. In 1886 the portion of the line from Astoria to Willets Point was levelled. In 1887 the line from Red Bank to Astoria and Dobbs Ferry was run. In 1894 and again in 1902 the line from Dobbs Ferry to Greenbush was establisht.

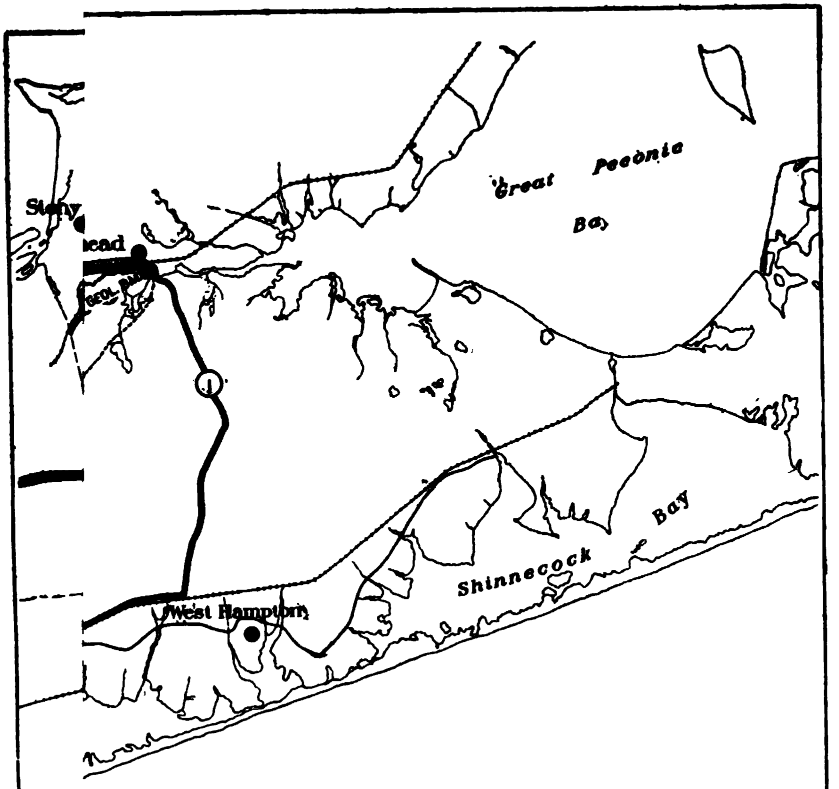
In 1886, the equipment consisted of metric rods fitted with targets, and Level No. 5 (described in Appendix 8, Coast an Geodetic Survey Report, 1898-99), which was fitted with a micrometer screw and a striding level with value of 1 division of bubble = 5.62 seconds. The method of levelling was as follows: The instrument was approximately levelled up, the end of the bubble was set against an even division of tube and the micrometer read. Then the target having been placed approximately in the horizon, the wire was set to bisect the target, and the micrometer was again read. Two rods were used as follows: "Rod A" was observed as backsight, and immediately afterwards while A was being carried forward, a backsight was taken on B, which had been placed near A. Then foresight readings were made first on A and immediately afterwards on B, near by. Thus two parallel lines were run simultaneously; a method abandoned in 1887 as not affording a complete check, the conditions of the instrument and of the atmosphere being the same for each line. The average distance from staff to staff was about 800 ft., but the instrument was generally not placed midway between. A and B were kept close together within a few meters.

The 1881 line was run in the same manner as above, except that the observer was required to run an independent third line, for a limited distance in a direction opposit to the two parallel lines, in order that the efficiency of the method of running parallel lines might be tested.

The 1887 levels were started by rerunning the 1881 line from Red Bank to Perth Amboy, thence diverging to Staten Iland, crossing the Narrows and connecting with the 1886 line at Astoria, thence to Forty-second Street, New York, and to Dobbs Ferry, as shown on Plate 55. At Raritan Bay the lines of 1887 differ from 1881 by 0.106 ft. between bench marks VIII and F. The 1887 line was accepted until 1898, at which time the 1881 line was re-adopted, as it apparently made the levels agree better with the tide gagings at Fort Hamilton and Governors Iland.

The 1887 lines differed from the above in the method of observing. Two single independent level lines were run, the line levelled in a forward direction being levelled in a backward direction on a different date, and instead of setting the bubble of the level against a selected division of the tube and recording the correspond-

PLATE 53.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.



U.S. GEOLOGICAL SURVEY BENCH LEVEL CIRCUITS

	RIVERHEAD SELDEN PATCHOGUE EASTPORT	PORT JEFFERSON SMITHTOWN NO. ISLIP [illegible]	PATCHOGUE HOLTSVILLE DEER PARK BABYLON	NO. ISLIP SMITHTOWN LARKFIELD BRENTWOOD
Length of circuit in miles	57	31	48	15
Error of closure in feet	0.65	0.13	0.09	0.23
Value of C in E = C√L	0.086	0.023	0.013	0.059

Two or more level-runs shown thus..................
U.S. Coast & Geodetic lines shown thus..................
U.S. Geological Survey lines shown thus..................
B.H.P. Com'd line shown thus..................
U.S. Geological Survey BMs shown thus.......... ⊕
The circuits in Suffolk Co. are single line levels except
the Base Line along Montauk Div, L.I.R.R.

City of New York
BOARD OF WATER SUPPLY
BENCH LEVELLING
JANUARY 31, 1906

Miles

Drawn
Traced
Checked

Acc. [illegible]

PLATE 64.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.

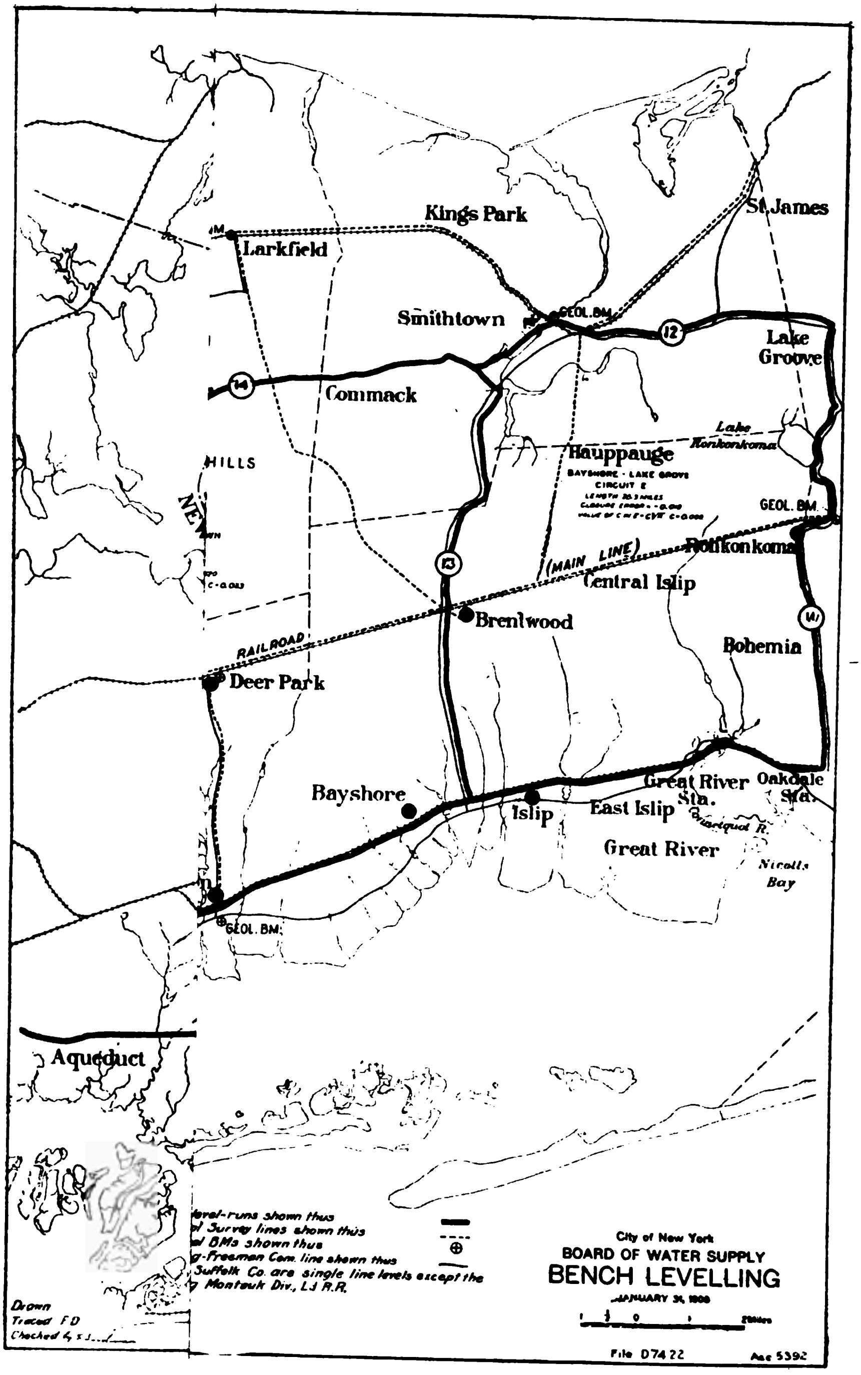
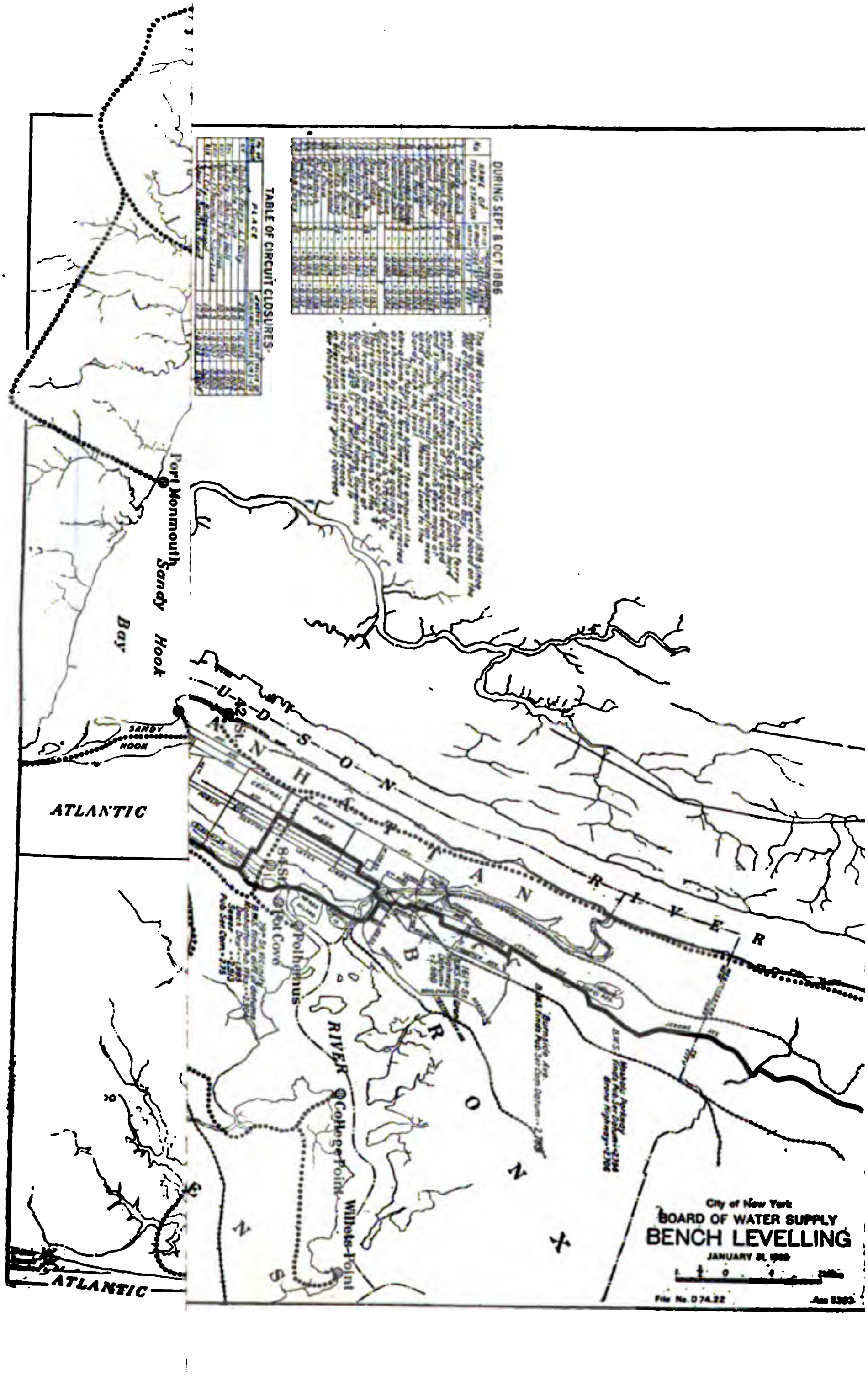


PLATE 55.
THE MUNICIPAL ENGINEER
OF THE CITY OF NEW YORK
GOODMAN ON BENCH LEVEL
AND NEW YORK CITY DATUM



City of New York
BOARD OF WATER SUPPLY
BENCH LEVELLING
JANUARY 31, 1909

File No. D 74.22
Acc 5303

PLATE 56.
THE MUNICIPAL ENGINEER
OF THE CITY OF NEW YORK
GOODMAN ON BENCH LEVEL
AND NEW YORK CITY DATUM

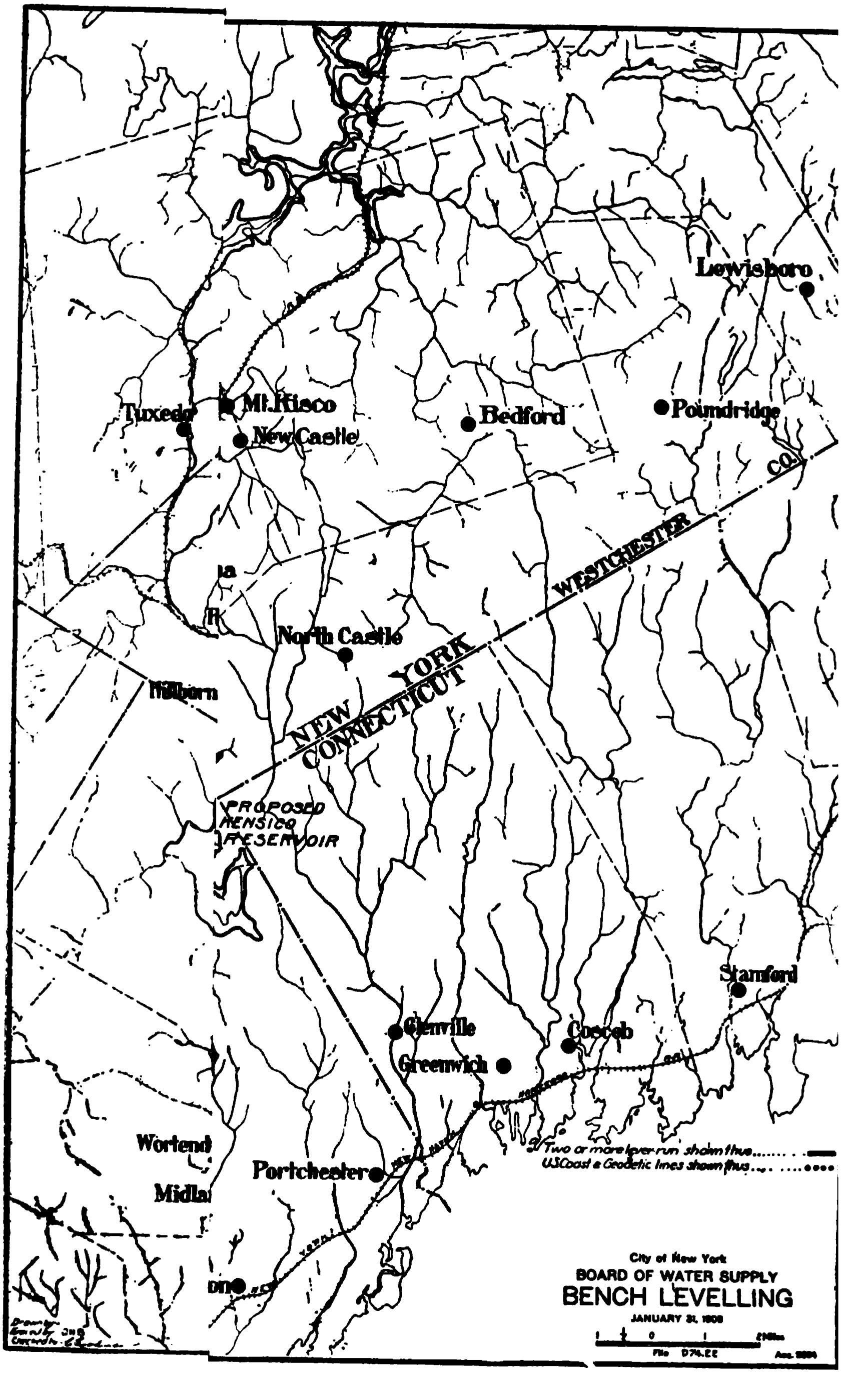


PLATE 57.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.

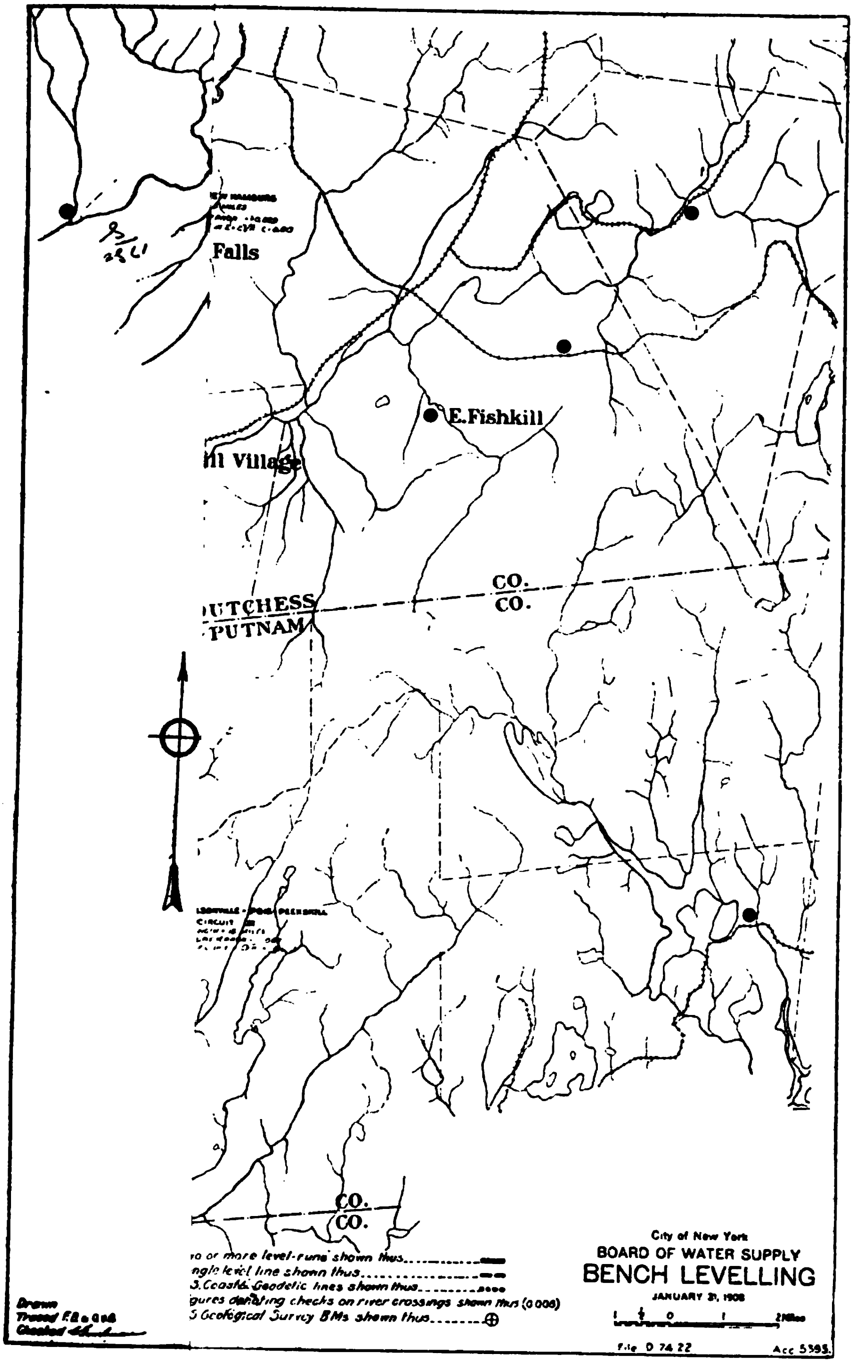

Falls
E.Fishkill
ll Village
UTCHESS CO.
PUTNAM CO.
CO.
CO.
ro or more level-runs shown thus
ngle level line shown thus
S. Coast & Geodetic lines shown thus
gures denoting checks on river crossings shown thus (0.006)
S Geological Survey BMs shown thus ⊕
Drawn
Traced F.B. & G.H.B.
Checked
City of New York
BOARD OF WATER SUPPLY
BENCH LEVELLING
JANUARY 31, 1908
1 ½ 0 1 2 Miles
File D 74 22
Acc 5395.

PLATE 58.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.

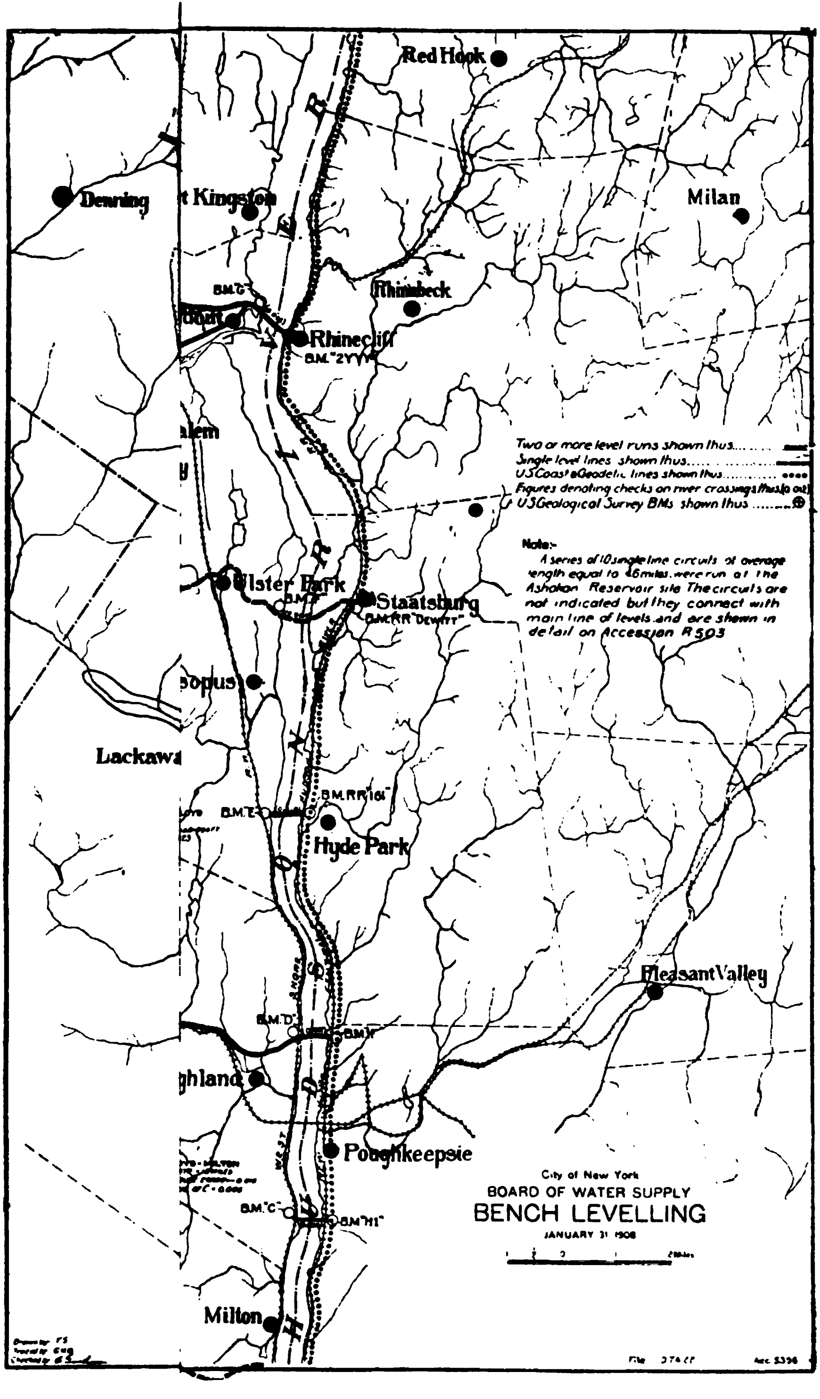
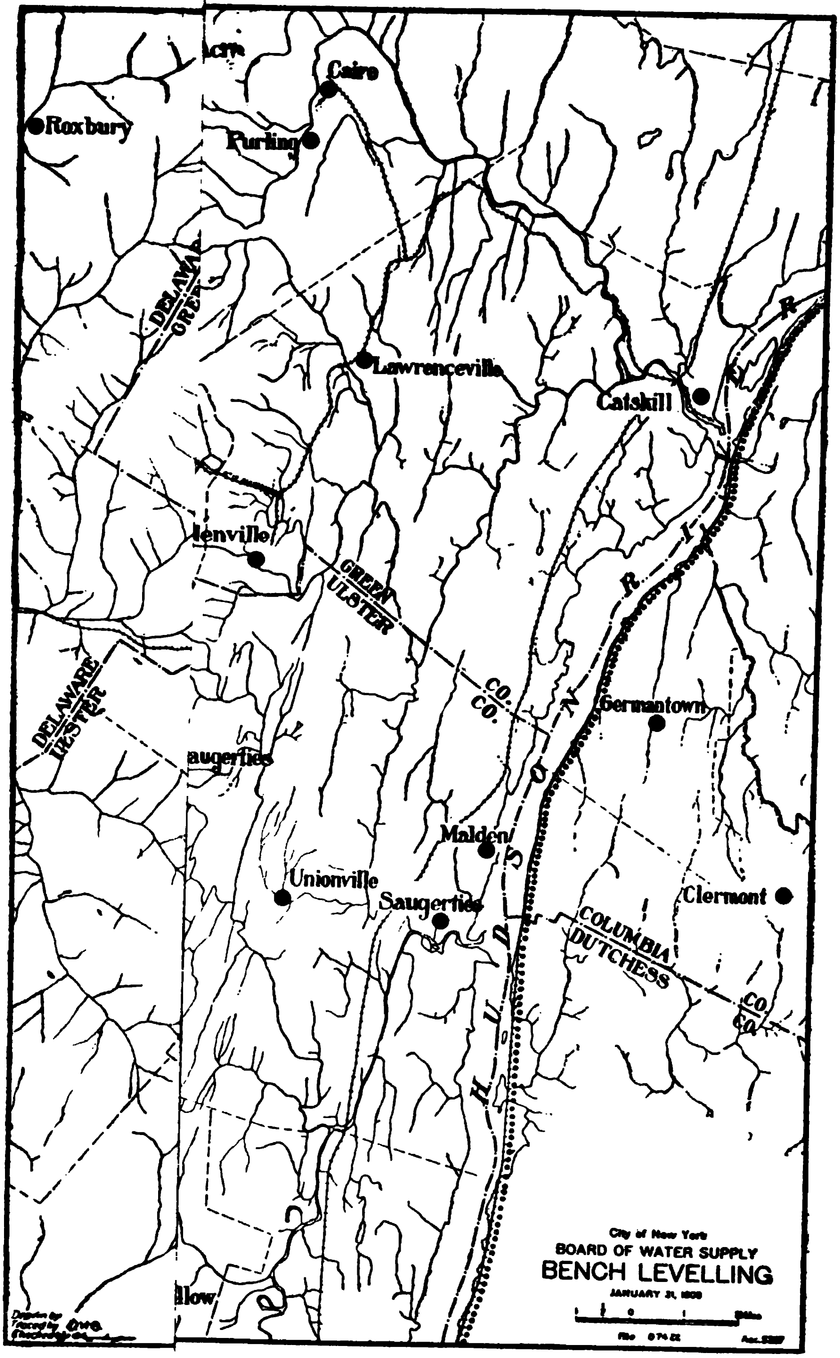

Red Hook
Denning
t Kingston
Milan
B.M."G"
Rhinebeck
Rhinecliff
B.M."ZYYY"
alem
Two or more level runs shown thus
Single level lines shown thus
U.S.Coast & Geodetic lines shown thus
Figures denoting checks on river crossings thus (o oo)
U.S.Geological Survey BMs shown thus ⊕
Note:-
A series of 10 single line circuits of average length equal to 46 miles, were run at the Ashokan Reservoir site. The circuits are not indicated but they connect with main line of levels and are shown in detail on Accession R 503
Ulster Park
B.M."F"
Staatsburg
B.M.RR"Dewitt"
sopus
Lackawa
B.M.RR"16"
B.M."E"
Hyde Park
Pleasant Valley
B.M."D"
B.M."I"
ghland
Poughkeepsie
City of New York
BOARD OF WATER SUPPLY
BENCH LEVELLING
JANUARY 31 1908
B.M."C"
B.M."H1"
Milton
File 374 CC
Acc. 5396

PLATE 59
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.



ing micrometer reading, the bubble was set exactly in the middle of the tube. The target was set approximately at the horizon of the telescope, and the successiv operations were then as follows:

(1) Reading micrometer for bubble in middle;

(2) Reading micrometer for backsight on target;

(3) Reversing striding level on collars:

(4) Reading micrometer for bubble in middle;

(5) Reading micrometer for backsight on target;

(6) Inverting telescope about its axis (to correct for collimation error);

(7 to 11) Repeating first 5 operations;

(12) Reversing instrument 180° in azimuth;

(13 to 23) Repeating above operations for the foresight.

The average distance from rod to rod, when grades did not force shorter sights, was about 750 ft.

Each observer furnisht a complete reduction of his work, and at the office a second and more elaborate computation was made. The means of the readings of the horizon and the target were made out and the corrections to the latter for micrometer differences, for inequality of collars, for refraction and curvature, severally applied, and the difference of elevations of two stations is further corrected for expansion or contraction of the brass scales (set at the center of the rod), when the temperature differs from the standard temperature at which they are of normal length. The index correction of the rods is applied whenever needed. The reduction is facilitated by tables depending on the instrumental constants and other data of the measures. The results being collated and any appreciable difference corrected or explained, the probable errors of the operation are reduced, and the final results are tabulated and reported upon.

In 1894, the instrument and rods were similar to those used on the above lines. A double simultaneous line was run as in the 1886 levelling, but the target was set when the bubble was in the center of the tube, and back and fore sights were kept equal and about 250 ft. in length. This method did away with elaborate computations, as the instrumental defects of adjustment and inequality of collars, and the effects of curvature and refraction were eliminated by keeping the back and fore sights equal. This line was considered by the Coast Survey to be an inferior one, and it was superseded in 1902 by a line using the approved instrument and methods of the present time.

The level, equipment and observation methods of the 1902 line are described in detail in Appendix 3, Coast and Geodetic Survey Reports of 1903. The method briefly consisted of reading, with the bubble in the center, and with each of the three wires of the instrument, self-reading rods placed at equal distances from the instrument, one at back sight and the other at fore sight. Readings were taken rapidly so that the time between the back and fore sights should be a minimum. A single line was run in one direction, and the backward line was run under different weather conditions on other days.

TIDE GAGINGS AND LEVELLING CHECKS.

The datum, mean sea level, was establisht from tide gagings at Sandy Hook, 1876-1881. The level thus found was checkt within 0.03 ft. by including and averaging with the tide gagings of 1882-1884 and 1886-1888. (Plate 63.)

During September and October, 1886, a series of simultaneous tide gagings for short periods were made at Sandy Hook, Lower and Upper Bay, and East and Hudson River, as shown on the New York map. (Plate 55.) These gagings were connected by the 1886-1887 level lines; the results, described and tabulated on Plate 55, show the sea level check on the accuracy of the level line. The apparent correction to the level line as shown by gagings is very nearly the same for Quarantine Dock, Governors Iland and Willets Point, thus indicating the levelling between those points to be of high accuracy.

The variation from year to year of gagings for mean sea level is considerable; therefore, in checking between sea level at different points, it is safe only to use simultaneous gagings at those points. The 1876-1881 gagings at Sandy Hook give the elevation of mean sea level as zero. The results of 1876-1878 from hourly ordinates show Sandy Hook mean sea level = Elevation + .017 while the simultaneous gagings at Governors Iland (hourly ordinates) establishes a mean sea level which is found from the Sandy Hook level line to be at Elevation — .075. As the error of each tide gaging may be .05 or more, this gives an excellent check on the level line from Sandy Hook to Governors Iland.

The Board of Water Supply level line checkt almost exactly between a bench mark at Brooklyn City Hall (establisht from Sandy Hook precise level line) and the tidal bench mark "M" at Fort Hamilton. (Establisht from the Coast and Geodetic Survey gagings for mean sea level 1892 to 1906.)

On page 404, Appendix 8 of the 1899 Coast and Geodetic Survey Report, it is stated that the mean sea level at Fort Hamilton, from the 1893 to 1899 tide gagings, is found by the level line to be at Elevation + .07. Now from a study of the bench mark tabulation on Plate 69 it will be seen that the Public Service Commission check closely between "Prim K" and tidal bench mark "M"; further that the Board of Water Supply line is checkt closely from "Prim J" to Fort Hamilton by several city departments, which check almost exactly between "Prim J," Bay Ridge, and "Prim K" at Bath Beach. Attention is also called to the discrepancy that the Dock Department discovers between "Prim L" (destroyed in 1902) and Bath Beach. The final conclusion would appear to be that Tidal "M" is in close agreement with the Sandy Hook precise level line bench marks, or mean sea level is the same for Sandy Hook or Fort Hamilton.

This conclusion is held by the Government at the present time, as shown in a letter of February 17, 1908, from Mr. O. H. Tittman, Supt. U. S. Coast and Geodetic Survey, which states: "There is no information available at this office proving that mean sea level at Fort Hamilton is at a different elevation from mean sea level at Sandy Hook; therefore, it is believed here, that the datum of the 1887 levelling (mean sea level at Sandy Hook) is the same as the datum to which the tidal bench marks at Fort Hamilton are referred, namely, mean sea level at Fort Hamilton." Further, Mr. Tittman states that: "As there is no direct connection by accurate levelling by this survey between the tidal bench mark and the bench marks of the precise level lines, it is to be expected that connections by levelling between the tidal bench marks may develop discrepancies due to the unavoidable uncertainties in the determination of mean sea level by the tidal observations at Fort Hamilton, which may be as great as .04 ft.

PERMANENCE OF MEAN SEA LEVEL.

A datum to be of scientific value should be enduring and susceptible of accurate determination. The most permanent level known is mean sea level. A sinking of the land will cause a change in elevations of the bench marks with respect to mean sea level, and it therefore becomes of considerable importance to determin whether a change in the land level occurs. The evidence (Plate 63) from the tide gagings in the vicinity of New York is as follows:

From 1886, continuously to date, the Department of Docks and Ferries have taken automatic tide gagings at Pier A, North River, near the Battery. From the tabulation on Plate 63, it is noticeable that half tide varies (mean low water = 0) from a minimum elevation of 1.75 in 1886 to a maximum of 2.53 in 1901, a variation of nearly 0.8 ft., altho the value for any one year is probably correct to 0.05 ft. An average curve thru the results would show half tide to apparently rise at the rate of 0.03 ft. per year. On the other hand, the elevation of 1889 is nearly the same as that of 1904.

The Fort Hamilton results from 1892 to 1902 apparently show a rise in sea level of .020 per year.

The elevation of sea level at West Fifty-seventh Street varies in a peculiar manner. The relation to the Battery gagings for the years 1886 to 1888 is absurd, and makes the results for those years for both places in dout.

From one month's simultaneous hourly reading at Sandy Hook, Lower Bay and Dobbs Ferry, the Coast and Geodetic Survey found Dobbs Ferry sea level to be about 2 in. above that of the Lower Bay as given by elevations of the level line.

At Croton Lake bench mark SL (Plate 69), the Croton datum is found to be higher by 0.510 ft. than the Coast and Geodetic Survey datum. Assuming the sea level at Ossining (north of Dobbs Ferry) to be 2/10 ft. higher than at the Lower Bay, then the sea level, from this evidence, changed since the bilding of the Old Croton Aqueduct (about 1842) 0.31 ft., or at the rate of 0.004 per year. The evidence as to the origin of this datum, and the levels based upon it is as follows:

A letter written in February, 1908, to the author by Mr. B. S. Church, formerly Chief Engineer of the Aqueduct Commission, states:

"The datum is based on mean tide at Ossining (Sing Sing) steamboat landing, which is about three miles from the mouth of the Croton River. This point at Ossining was the broadest part of the Hudson River and far enough below the mouth of the Croton to prevent the fluctuation of flow in that stream from affecting the datum fixed at Ossining.

The authority for these statements is Mr. John B. Jervis, constructor of the Old Croton Aqueduct, given to B. S. Church, personally."

Again in a letter of September 17, 1908, Mr. Church states:

"You can feel assured that the New Croton Aqueduct B. M. at Old Croton Dam, and the levels of the New Croton Aqueduct, as constructed, were accurately based on the Old Croton datum. They were taken from the masonry lip of the south wasteway of the Old Croton Dam, which rests on rock, and has strongly preserved the standard of the datum as a permanent bench. Its elevation is 166.93 above Croton datum.

Having had charge of the Old Croton Aqueduct for twenty-five years, I have reason to know that it was bilt with precision, and, therefore, it is good judgment to infer that the line of levels from Ossining to Old Croton Dam were accurately done by its engineers.

As to their method and period of tide gaging at Ossining, I know no more than I have previously given you.

As their Ossining gagings would give a datum safely above city gagings, it was not necessary to be specially particular about the method or period of taking them.

Now if these Ossining gagings were taken during full flow of the Hudson River from its watershed, and crowding from the narrow neck at Fort Washington point from the Tappan-Zee, it would probably account for the difference of 0.51 ft. between Ossining and the lower bay of New York City."

Mr. Webster, Engineer of Street Openings, Manhattan, discussing the Public Works datum of New York City, states a general impression exists that the duration of tide gagings for mean high water was about 5 years, and that they were made about 1820, and that the tide gagings are tied in to an existing monument at Bellevue Hospital, East River, and further that the monument was connected by five or six careful level lines by his department to the "T." B. M. at New York City Hall, making the elevation of the latter 42.21 ft.

At the "T." B. M. at New York City Hall, the Datum Planes Committee of The Municipal Engineers find the difference from the Coast Survey datum to be 2.67 ft. On Plate 63 is shown tide gagings at East Twenty-fourth Street. An average range of tide of 4.12 ft. exists for the five consecutiv years, 1900 to 1904, inclusiv. This shows mean high water to be 2.06 ft. above an average mean sea level, which may be considered the same as the government mean sea level. Therefore, a difference of .61 ft. (2.67 — 2.06) appears to exist between that of 1827 and the present average mean high water, indicating a rate of rise in the sea level of .009 ft. per year.

The mean high water establishing the Brooklyn Navy Yard datum is discust on page 649 of the Burr-Hering-Freeman Commission's Report on Additional Water Supply, and in the report of the Special Committee on Datum Planes on page 208 of the *Procedings* of this Society for 1905. The first of the above reports states that mean high water, from the tide gagings of 1840-43, is 5 ft. below a bench mark on the coping of Dry Dock No. 1. Assuming the present range of tide at the Navy Yard as 4.17 ft. (about half that of the Battery and East Twenty-fourth Street) this would make mean high water about 2.09 ft. above an average mean sea level, and as the elevation above the government sea level of the above bench mark is 6.76 ft., this makes the bench mark 4.67 ft. above mean high water; a change of .033 ft. since the tide gagings of 1840, indicating a rate of rise of the sea of .007 per year.

The probable origin of the statement that the Navy Yard B. M. is 5 ft. above mean high water is found in the miscellaneous papers of Mr. Wm. L. McAlpine (Engineer and Contractor, 1845-49) on the Brooklyn Dry Dock, recording the following extract from a letter of Col. Baldwin (who made the preliminary surveys and examination for the location of the dock in 1835): "The point of high water, from which this 25 ft. is measured, is that point where two thirds of the tides for the year reach the hight or above it" and "Coping 5 ft. above the mark."

The complete tide gagings mentioned above and other data from page 653 of the Burr-Hering-Freeman report, is tabulated and graphically plotted on Plate 63.

Special attention is directed to the table of annual inequality, which shows a maximum variation of mean sea level between months of the same year of 0.7 ft. and also to the Dock Department, Fifty-seventh Street and Fort Hamilton gagings, showing mean sea level variation from year to year, and for periods of years, separated from each other by varying times. This clearly shows that tide gagings for the mean sea levels, to be of value, should be an average of a great number of consecutiv years.

The best evidence of rise of sea level appears to be the gagings originating the Public Works, Navy Yard and Croton datums, but in each case there does not appear a thoroly reliable existing record of the methods and periods of the gagings which the variations of sea values demand for satisfactory evidence. On the other hand, the mean sea level from the reliable government observations of 1876-81 at Sandy Hook, does not differ materially from the Fort Hamilton gagings of 1892-1906, so that a fair conclusion appears to be that while it is possible that the sea level in vicinity of New York is changing and rising, it can only be determined definitly by reliable gagings over a long period of years.*

ORGANIZATION OF PARTIES.

Following the recommendation of Mr. Robert Ridgway, Department Engineer, two bench level parties were organized November 4, 1905. Assistant Engineer J. J. Blake was in charge of Party No. 1 until July 1st, 1906, when he severed his connection with the Board, and the author was then placed in charge. Party No. 2 was in charge of Assistant Engineer M. E. Zipser. At the time of organization each party consisted of the assistant engineer in charge, who acted as instrument man, and two rodmen. Later on when the 3-wire level equipment was adopted, an additional man was added to each party, who acted as recorder.

At the beginning of the work, general instructions were given to each party. These in brief required: (1) That the Coast and Geodetic Survey bench marks should be used as primary bench marks; (2) that Geological Survey bench marks be used as checks where practical; (3) that spur lines should be run from the primary bench marks to the aqueduct line (a double line to be run by each party) and these lines connected by levels approximately along the proposed aqueduct line; (4) both parties to work together at the same time

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*Further detailed evidence of stability of mean sea level is found in the paper and discussion of the Report of Special Committee on Datum Planes on pp. 210, 211, 220 to 224 of the *Procedings* of this Society for 1905.

for levelling across the Hudson river; (5) the limit of error was fixt at .03 ft. $\sqrt{\text{distance in miles}}$; (6) dumpy level and New York rods to be used; (7) method of levelling to be that hereafter described as Method 1; (8) bench marks to be establisht at convenient locations; to be of a definit character and permanence, and at intervals not exceeding one-half mile convenient to the aqueduct line.

The levelling in the Reservoir Department, which covered the Ashokan Reservoir and extended to Prattsville, was completed in 1907. These levels were run by one of the local parties consisting of one assistant engineer, acting as instrument man, and two laborers acting as rodmen. During the first half of 1908, the relevelling, for setting the standard B. Ms. of the Northern Aqueduct Department was largely completed by Party No. 1, and in addition a main line of levels were run from High Falls to Napanock and Lackawack.

In the Northern Aqueduct Department the entire work was done at different intervals of time, viz., the first levels from Peekskill to the Ashokan Reservoir were run by Parties 1 and 2 between November 4, 1905, and November 3, 1906.

In the Southern Aqueduct and Headquarters Departments Party No. 1 completed levelling connecting Peekskill, N. Y., with Rockville Center, Long Iland, between September 3, 1907, and December 18, 1907.

In the Long Iland Department Party No. 1, with a total of four men, completed the work from Rockville Center east to Riverhead between November 7, 1906, and February 7, 1907.

THE EQUIPMENT.

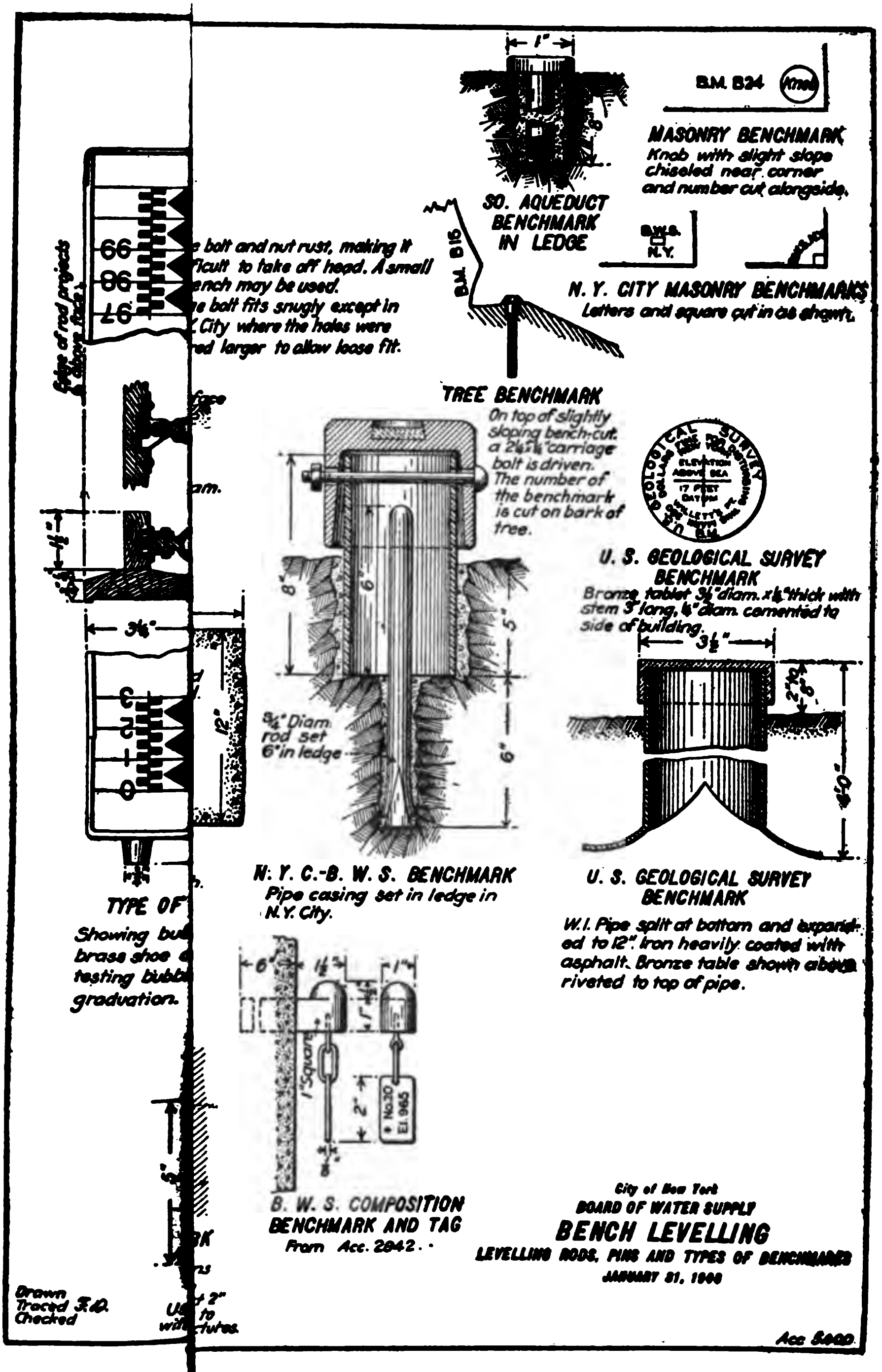
METHODS NOS. 1, 2 AND 3.

At the beginning of the work, and during the time methods 1, 2 and 3 described hereafter were in use, the equipment of each party consisted of an 18-in. Buff and Buff erecting dumpy level, as used in ordinary levelling, two New York extension rods, provided with special bisection targets (Plate 60); steel turning point pins, 8 in. long, with rounded heads, and rod levels for plumbing the rods.

METHOD NO 4.

With this method the equipment (excepting for about 10 days) consisted of a 15-in. Berger dumpy level, as used in ordinary levell-

PLATE 60.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.


1"
8"
SO. AQUEDUCT BENCHMARK IN LEDGE
B.M. B24
Knob
MASONRY BENCHMARK
Knob with slight slope chiseled near corner and number cut alongside.
B.W.S. N.Y.
N. Y. CITY MASONRY BENCHMARKS
Letters and square cut in as shown.
B.M. B16
TREE BENCHMARK
On top of slightly sloping bench-cut a 2½x¼" carriage bolt is driven. The number of the benchmark is cut on bark of tree.
U.S. GEOLOGICAL SURVEY
ELEVATION ABOVE SEA
17 FEET
DATUM
U. S. GEOLOGICAL SURVEY BENCHMARK
Bronze tablet 3½" diam. x ¼" thick with stem 3" long, ½" diam. cemented to side of building.
3½"
2½"
6"
4'0"
U. S. GEOLOGICAL SURVEY BENCHMARK
W.I. Pipe split at bottom and expanded to 12". Iron heavily coated with asphalt. Bronze table shown above riveted to top of pipe.
8"
6"
5"
6"
¾" Diam rod set 6" in ledge
N. Y. C.-B. W. S. BENCHMARK
Pipe casing set in ledge in N. Y. City.
6"
1½"
1"
1"
1" Square
2"
No.20 El. 965
B. W. S. COMPOSITION BENCHMARK AND TAG
From Acc. 2842.
City of New York
BOARD OF WATER SUPPLY
BENCH LEVELLING
LEVELLING RODS, PINS AND TYPES OF BENCHMARKS
JANUARY 31, 1908
Acc. 5000.
99
98
97
Edge of rod projects 1/8" above face
e bolt and nut rust, making it
ficult to take off head. A small
ench may be used.
e bolt fits snugly except in
C. City where the holes were
red larger to allow loose fit.
face
am.
1¼"
3⅛"
12"
3
2
1
0
TYPE OF
Showing bu
brass shoe a
testing bubb
graduation.
5"
RK
s
U d 2"
to
wit tures.
Drawn
Traced J.F.D.
Checked

ing, 2 rods of the Molitor type, and turning point pins, as shown on Plate 60.

The Levels.—The Berger level gave an inverted image, and was fitted with three horizontal and one vertical wire. The principal parts were as follows:

Length of telescope	15 in.
Focal length of telescope	13 "
Magnifying power	27
Diameter of objectiv	1¼ in.
Angular value of 1 div. of bubble	13 sec.

At 200 ft. extreme wires cover 1 foot on rod.

A noteworthy feature of the above level was its constancy in remaining in adjustment as determined by frequent tests made by each of the parties. From the test of January 2, 1906, Party No. 1 found the error of instrument to be .001 in 100 ft. This error varied, but was never more than .001 in 50 ft., so that, altho subject to the jarring and rough usage of mountain work, it was not found necessary by either of the parties to change the adjustment of the instrument during the levelling.

One objection to the above level is that the heat in summer causes the bubble to shrink to a size which seriously interferes with precise work. This could be remedied by making the bubble adjustable for length. Furthermore a more activ bubble would be preferable where it is always to be observed when the sight is taken.

During a period of ten days, about December 1, 1907, a level constructed by Keuffel and Esser was in use, similar in design to the precise level described in Appendix 8, Report of 1903, of the United States Coast Survey. The parts of this level were:

Angular value of 1 division of bubble	8 sec.
Length of telescope	16 in.
Magnifying power	35
Diameter of objectiv	1⅝ in.

At 200 ft. extreme stadia wires cover 1 ft. on rod.

The bubble of this level was air chambered and adjustable for length, and was centered by use of a micrometer screw. The instrument head weighed 15½ and the tripod 9 lb.

The operation of the bubble control in this instrument is to roughly level up with the levelling screws, the fine motion being made by the micrometer. It was found difficult to control the bubble. The Coast and Geodetic Survey experience is that the bubble will continue moving when the micrometer stops, and that it is necessary to know how many divisions to move the micrometer so that the bubble will stop in the exact center. This is acquired with experience, and then the method is rapid. Another feature of this level is that the telescope motion pivots about a point at the object-glass end of the casing tube, making it desirable to control the final motion with the micrometer screw. In reversing the level for fore sight, the bubble did not stay in the middle of the tube, but required considerable relevelling.

It was found that the bubble could be more quickly controlled by pressure with the hand at the base of the instrument, and that while for long sights the extra time necessary to control and manipulate the instrument did not matter, due to the rodmen walking greater distances, on short sights there was an actual delay in comparison with the speed of the Berger 3-wire level.

The Rods.—The rods shown on Plate 60 accompanying this report are similar to the Molitor rods used by the U. S. Coast and Geodetic Survey, but differ in graduation. The rod is a white pine board (not paraffined), with a rib in the center of the back extending the length of the rod to prevent warping, the whole forming a T cross section. The edges project about 1/10 in. from the face of the rod, and form a protection for graduations. A cylindrical shoe forms the base, and a bubble which can be folded back is permanently attacht at the back of the rod. Two brass pieces, an eye and a sharp point fixt at the top and bottom respectivly, define a line parallel to the face of rod. When this line is made to coincide with a plumb line, the bubble should indicate, or be adjusted to indicate, a plumb rod. Removable handles complete the rod. The length of these rods is a little more than 10 ft. and the graduations are uniform thruout. The method of graduation is shown on Plate 60. The triangle at the left face of the rod is of great value in defining the tenths and ½-tenths marks.

The rods used by Party No. 2 did not have the foot markt at each tenth. This is objectionable for if all three wires fall between two foot marks, the reading may be wrong by an even foot.

In the Reservoir Department their extension rods were compared with an engineer's steel tape, and corrections were made in the computations for the errors found. The tests of rods for the remaining work are tabulated on Plate 62, and a curve drawn showing the variation of rod lengths as found from many tests. Various methods of testing rods were used. The simplest method was used for the levelling south of the Northern Aqueduct Department, and consisted in selecting a smooth floor, such as that of a ballroom or office bilding, laying the standard tape along a chalk line on the floor, marking off 50 ft. (both ends of a 100-ft. tape were used and average taken), then marking off the length of rods on an auxiliary tape and applying the marked distance along the base line. The measurements were repeated two or three times. The total of the auxiliary tape measurements is the distance measured by rods and comparing this with the actual distance shown by the standard tape, the correction of the rod is obtained. This method carefully applied is very accurate, and in addition to its simplicity, the fact that tests are always made in shady places where rods are kept over night, make it desirable for all rod tests. A thin planed strip of wood 10½ ft. long might be used to advantage instead of the auxiliary tape.

Rod Corrections.—As shown by the curve on Plate 62 the variation in length of the rods from time to time was considerable, and at the beginning of the work considerable trouble was experienced due to rod changes. Later, when the aqueduct line was definitely fixt, and the final bench levels run, most of the early levels were superseded by new levels, which were run immediately after the New Paltz test (described on Plate 62), which test was used in the final adjustment.

The reruns between B. Ms. having considerable differences in elevation, gave at most points entirely different results, showing the necessity of frequent rod tests when using non-paraffined rods.

On the line from High Falls to Lackawack, which was run in May, 1908, daily comparisons of rod with a standardized 10-ft. steel tape were made, and the daily corrections used in the final adjustments.

During Headquarters work and between the Valhalla test of September 23 and the 299 Broadway test of January 8th, a remarkable change was noticed in the rods. It became necessary to rerun some bench marks to locate a change. The rerun of January 18 of bench marks S60-S61 showed that the Valhalla test was correct for former run of October 22, 1907. Therefore this was applied to South Aqueduct levels, from Hunters Brook to the New York City line.

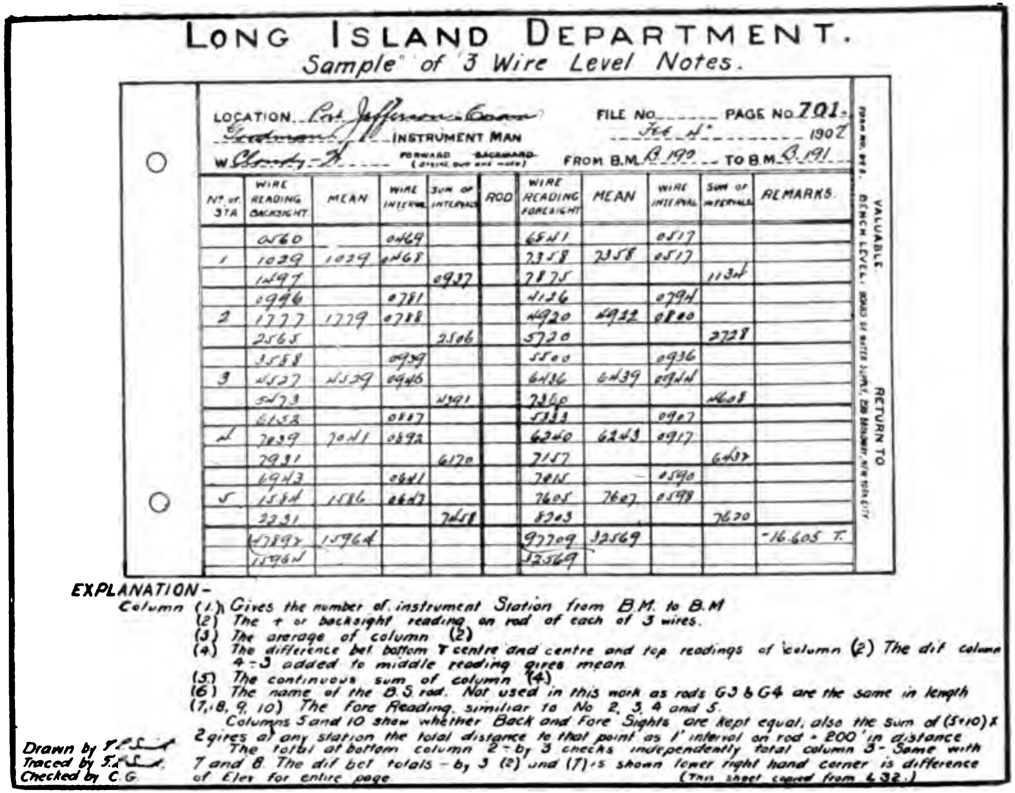
On October 22 the level line was run south from the City line thru Manhattan to Blackwell's Iland, and the return line was run on October 29th. A divergence of .06 ft. was found for the 223 ft. difference of elevation between the city line bench mark and East One Hundredth and Sixty-first Street, a rate of nearly .03 ft. per 100 ft. difference of elevation. Again on the short distance B. Ms. Na to N2, the runs varied .013 ft. for 38 ft. difference of elevation, or at rate of .034 ft. per 100 ft. rise. It was therefore decided that the rod changed .03 ft. per 100 ft. rise between the city line and the East River, making the correction of rods at East River zero. The average of the Valhalla and the East River corrections, .014 ft. per 100 ft. rise, was used for part of the line affected.

In Brooklyn the runs between the bench mark at Bradley Avenue and N10, a distance of 1 300 ft., with a difference of elevation of about 40 ft., checkt within .004 ft., showing no rod change between the runs of November 15th and December 11th. The run of January 14th between Public Service bench marks in South Brooklyn, between Fortieth and Ninth Avenue, and Fortieth and Seventh Avenue, checkt the November 29th result exactly. As this is a short distance of 1 500 ft., with a difference in elevation of 38 ft., it showed no rod change between November 29th and January 14th. Therefore, as no change occurred in the rods between November 15th and January 14th, the correction used for the levels from Blackwell's Iland to Rockville Center, and Staten Iland, was that of the 299 Broadway test of January 8, 1908.

The rod-length error used for Long Iland levels from Rockville Center eastward was that determined from the Babylon test, because the temperature of the test (23° fahr.) was very nearly the actual temperature of the hilly part of the field work.

The rods, the changes of which are tabulated and shown graphically on Plate 62, were painted very carefully, but were not paraffined, in accordance with the advice of the makers, who stated that "the paraffin seems to weaken the wood in some way and after a time it becomes brittle and apt to break."

The experience of the Geological Survey (see p. 359, *Transactions*, Am. Soc. C. E., Vol. XXXIX) is that shallow paraffining,



LONG ISLAND DEPARTMENT.

Sample" of 3 Wire Level Notes.

LOCATION. Pt. Jefferson–Conn
Goodman INSTRUMENT MAN
W Cloudy–H FORWARD ~~BACKWARD~~ (STRIKE OUT ONE WORD)

FILE NO. ______ PAGE NO. 701.
Feb 4th 1907
FROM B.M. B.190 TO B.M. B.191

Nº of STA	WIRE READING BACKSIGHT	MEAN	WIRE INTERVAL	SUM OF INTERVALS	ROD	WIRE READING FORESIGHT	MEAN	WIRE INTERVAL	SUM OF INTERVALS	REMARKS.
	0560		0469			6841		0517		
1	1029	1029	0468			7358	7358	0517		
	1497			0937		7875			1134	
	0996		0781			4126		0794		
2	1777	1779	0788			4920	4922	0800		
	2565			2506		5720			2728	
	3588		0939			5500		0936		
3	4527	4529	0946			6436	6439	0944		
	5473			4391		7380			4608	
	6152		0887			5333		0907		
4	7039	7041	0892			6240	6243	0917		
	7931			6170		7157			6437	
	0943		0641			7015		0590		
5	1584	1586	0647			7605	7607	0598		
	2231			7458		8203			7620	
	47892	15964				97709	32569			-16.605 T.
	15964					32569				

FORM NO. 94 E. VALUABLE. BENCH LEVEL. RETURN TO BOARD OF WATER SUPPLY, 299 BROADWAY, NEW YORK CITY

EXPLANATION–
Column (1) Gives the number of instrument Station from B.M. to B.M.
(2) The + or backsight reading on rod of each of 3 wires.
(3) The average of column (2)
(4) The difference bet bottom & centre and centre and top readings of column (2) The dif column 4 – 3 added to middle reading gives mean.
(5) The continuous sum of column (4)
(6) The name of the B.S. rod. Not used in this work as rods G3 & G4 are the same in length
(7, 8, 9, 10) The Fore Reading, similiar to No 2, 3, 4 and 5.
Columns 5 and 10 show whether Back and Fore Sights are kept equal; also the sum of (5+10) x 2 gives at any station the total distance to that point as 1' interval on rod = 200' in distance
The total at bottom column 2 ÷ by 3 checks independently total column 3 – Same with 7 and 8. The dif bet totals ÷ by 3 (2) and (7) is shown lower right hand corner is difference of Elev for entire page. (This sheet copied from 432.)

Drawn by T. P. S.
Traced by S.
Checked by C. G.

SAMPLE OF THREE-WIRE LEVEL NOTES.

to a moderate depth of about ⅛ in., and again that of the Coast and Geodetic Survey (see p. 419, App. 8, 1899 Report), is that rods containing 20% of their original weight of paraffin, possess the proper resistance to atmospheric changes. A minimum of paraffin is desirable because the texture of the wood is changed when thoroly soaked with paraffin, making it soft and cheese-like and causing it to easily dent and bend.

On page 12 of the *Transactions* of the American Society of Civil Engineers, Vol. XLV, a partial saturation with linseed oil and surfacing with several coats of white zinc paint is recommended. The changes in the above rods is probably due to non-treatment of the wood. It is certain that had shallow paraffining been applied, the trouble experienced in regard to changes in the lengths of the rods would have been largely avoided.

The Pins.—Two noticeable types of pins were used and are shown on Plate 60. One of the pins, shown in cross-section, consists of a wrought-iron head lapwelded to a steel pin. This was driven in the ground with a mallet. This pin showed a tendency to break at the weld and could not be driven into hard, frozen ground. A second pin, similar, but turned out of one piece of tool steel, is shown as being recommended by Mr. M. E. Zipser.

The gravity pin designed by the author is simply a weight with a broad base which when shoved to rest is very stable. It was used in the streets of Greater New York with great success, and is recommended for all road levelling. It is much superior to the above pin for road work, as it is easily and quickly handled, and has a special advantage in frozen ground where it is almost impossible to drive any pins.

METHODS OF LEVELLING.

River Crossings.

Rivers were crost by having two parties work in conjunction as follows: The levels were set up on opposit sides of the river and the near rod sighted. Then each party alternately set the targets of the rods on the opposit shore. Each target was set from 6 to 12 times, the average being used for the final reading. After a number of satisfactory readings had been secured, the parties changed sides, taking their equipment with them, and the operation was repeated. The average was considered as one final difference of elevation.

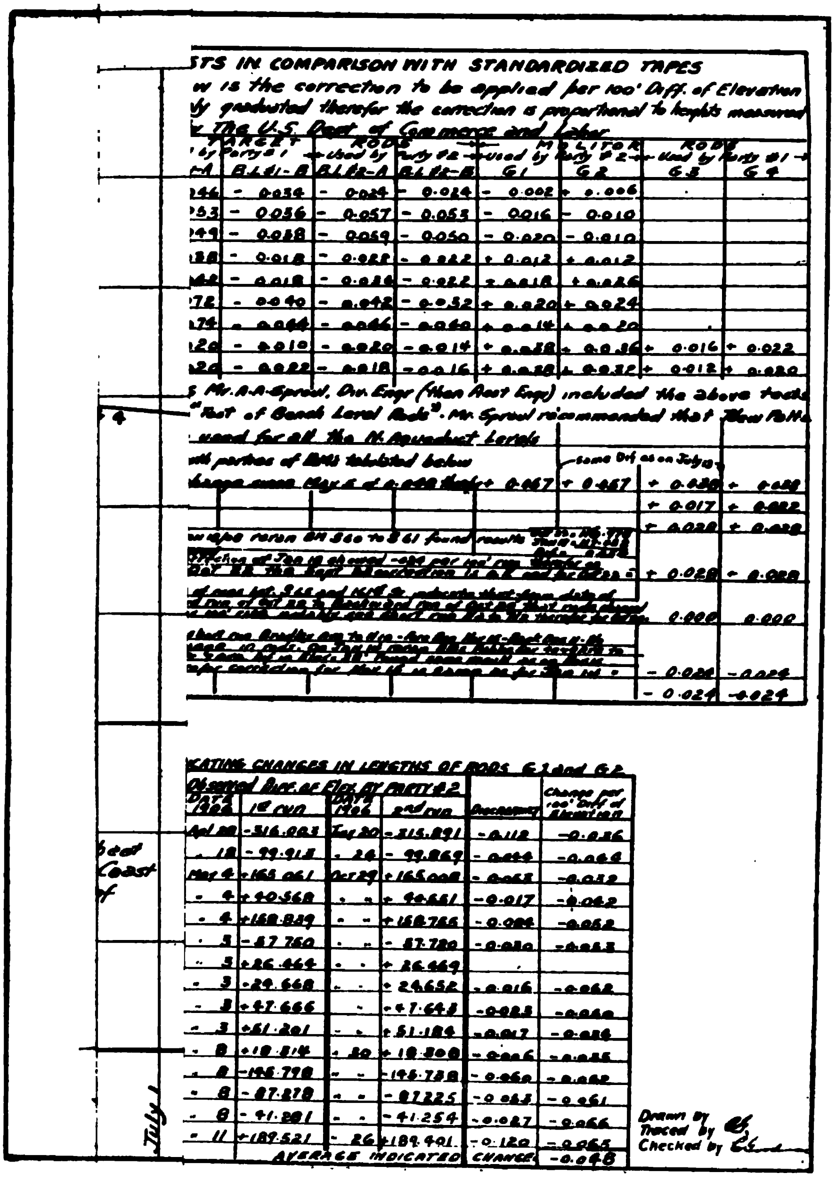
The above operations were generally repeated on some succeeding day, giving another difference of elevation, which was required to check the first result. The method is the usual one of simultaneous reciprocal levelling, eliminating curvature and refraction changes. A sample of notes and a list of the checks on river crossings are shown in Tables 3 and 8.

The writer found that air vibration or the unstability of the instrument stopt all river work. When the cross wires appeared to be steady on the target of the rod, the work could be accurately done on sunny or cloudy days. The main essentials are taking a number of simultaneous readings in rapid succession from both sides of the river. The narrows crossing, which was the longest sight of the work, was done on a cloudy day.

METHOD 1, TARGET RODS.

In the Northern Aqueduct Report on bench levels, Mr. Zipser describes methods Nos. 1, 2 and 3 as follows:

Method 1.—When the levelling was first begun, the method used was analogous to the reciprocal method employed in the river crossing, that is, the instrument was set up as close to the back-sight rod as the focussing of the instrument permitted (about 7 ft.) and both rods were read, after which another set-up was made close to the fore-sight rod and both rods read again, the mean of the two results being taken for the difference of elevation between the turning points. This method, outlined in the Northern Aqueduct letter of instructions, while theoretically perfect, is open to several serious objections, among which are the following: At certain times of the day, atmospheric changes take place very rapidly. When cold nights are followed by warm days, as was often the case during the last winter, the refraction changes are a maximum at about 9 o'clock A. M. and 4 o'clock P. M. At such times it was found that a rod reading at a distance of about 200 ft. would change materially, that is 0.004 or 0.005 in a short interval of time. In the above method, on account of the lapse of time between the two set-ups, this refraction error is not eliminated. Then again the heat effects may change the adjustment of the instrument between the two set-ups. One of the



STS IN COMPARISON WITH STANDARDIZED TAPES

w is the correction to be applied per 100' Diff. of Elevation
ly graduated therefor the correction is proportional to heights measured
e The U.S. Dept. of Commerce and Labor

TARGET	RODS			MOLITOR		RODS	
by Party #1	used by Party #2		used by Party #2			used by Party #1	
A	BL41-B	BL42-A	BL42-B	G1	G2	G3	G4
46	- 0.034	- 0.024	- 0.024	- 0.002	+ 0.006		
53	- 0.056	- 0.057	- 0.053	- 0.016	- 0.010		
49	- 0.038	- 0.059	- 0.050	- 0.020	- 0.010		
38	- 0.018	- 0.028	- 0.022	+ 0.012	+ 0.012		
42	- 0.018	- 0.028	- 0.022	+ 0.018	+ 0.026		
72	- 0.040	- 0.042	- 0.032	+ 0.020	+ 0.024		
74	- 0.044	- 0.046	- 0.040	+ 0.014	+ 0.020		
20	- 0.010	- 0.020	- 0.014	+ 0.038	+ 0.036	+ 0.016	+ 0.022
20	- 0.022	- 0.018	- 0.016	+ 0.038	+ 0.032	+ 0.012	+ 0.020

s Mr. A. A. Sproul, Div. Engr (then Asst Engr) included the above tests
"Test of Bench Level Rods". Mr. Sproul recommended that [illegible]
used for all the N. Aqueduct Levels

with portions of BMs tabulated below — same Dif as on July [illegible]

change since May 8 of 0.048 therefore + 0.467 | + 0.467 | + 0.030 | + 0.0[illegible]

+ 0.017 | + 0.022

+ 0.028 | + 0.028

w tape rerun BM 360 to 361 found results [illegible]
[illegible] of Tape is shown -.0[illegible] per 100' [illegible]
Oct 22 the Tape [illegible] correction is o.k. and for G1 G2 = | + 0.028 | + 0.028

[illegible]
[illegible] | 0.000 | 0.000

[illegible]
[illegible] for correction for May [illegible] is same as for June 1st = | - 0.024 | - 0.024

- 0.024 | - 0.024

CATING CHANGES IN LENGTHS OF RODS G1 and G2

Observed Diff. of Elev. by Party #2					
DATE 1906	1st run	DATE 1906	2nd run	Discrepancy	Change per 100' Diff. of Elevation
Apl 20	- 316.003	Jun 20	- 315.891	- 0.112	- 0.036
" 18	- 99.913	" 26	- 99.869	- 0.044	- 0.044
May 4	+ 165.061	Oct 29	+ 165.008	- 0.053	- 0.032
" 4	+ 40.568	" "	+ 40.551	- 0.017	- 0.042
" 4	+ 168.839	" "	+ 168.766	- 0.073	- 0.043
" 3	- 87.760	" "	- 87.720	- 0.040	- 0.046
" 3	+ 26.464	" "	+ 26.469		
" 3	+ 24.668	" "	+ 24.652	- 0.016	- 0.062
" 3	+ 47.666	"	+ 47.643	- 0.023	- 0.048
" 3	+ 51.201	" "	+ 51.184	- 0.017	- 0.033
" 8	+ 18.314	" 30	+ 18.308	- 0.006	- 0.033
" 8	- 146.798	" "	- 146.738	- 0.060	- 0.041
" 8	- 87.278	" "	- 87.225	- 0.053	- 0.061
" 8	- 41.281	" "	- 41.254	- 0.027	- 0.066
" 11	+ 189.521	" 26	+ 189.401	- 0.120	- 0.063
	AVERAGE INDICATED CHANGE				- 0.048

Drawn by
Traced by
Checked by

4

eet
Coast
of

July 1

ANGES IN

essential requirements in accurate levelling is to reduce the interval of time between corresponding back and fore sights to a minimum. The speed of levelling in the above method is, under the most advantageous conditions, only about one-half of that in the usual methods of taking approximately equal back and fore-sight distances, and since the cost is very nearly proportional to the speed, the cost per mile becomes excessiv. On heavy grades the method is out of the question.

As the foregoing method principally aims at the elimination of errors due to unequal length of sight, this result can be accomplisht by pacing the distances. Our experience has shown that a dumpy level can be depended upon for holding its adjustment. The error of the instrument used by Party No. 2 was generally about .001 ft. in a horizontal distance of 50 ft. Since the instrumental error affects only the excess in length of the back sight over the fore sight, or *vice versa,* equalizing the distance by pacing will be sufficiently good for the type of instrument used and the accuracy imposed.

METHOD 2, TARGET RODS.

Method 1 was superseded after three weeks' trial by the usual method of making back and fore-sight distances approximately equal. At first two set-ups were made between turning points. When the first circuit of levels was closed, it was found that the result obtained by the mean of the two sets of observations did not differ materially from either set taken singly; in fact, the first set gave a better circuit closure than the mean of the two sets. As far as accuracy is concerned, two sets of target readings taken at the same time, on the same turning points and in the same direction, has, in the judgment of the writer, no advantages. It has the great disadvantage of reducing the speed by about 33%. Of course, the repetition serves as a check on the target readings.

METHOD 3, TARGET RODS.

Subsequently one set-up was made between the turning points and each rod was read once, the instrumentman checking the target settings himself as the rear rodman came up and as he past the forward rodman. The other details of this method were in accordance with the usual practis.

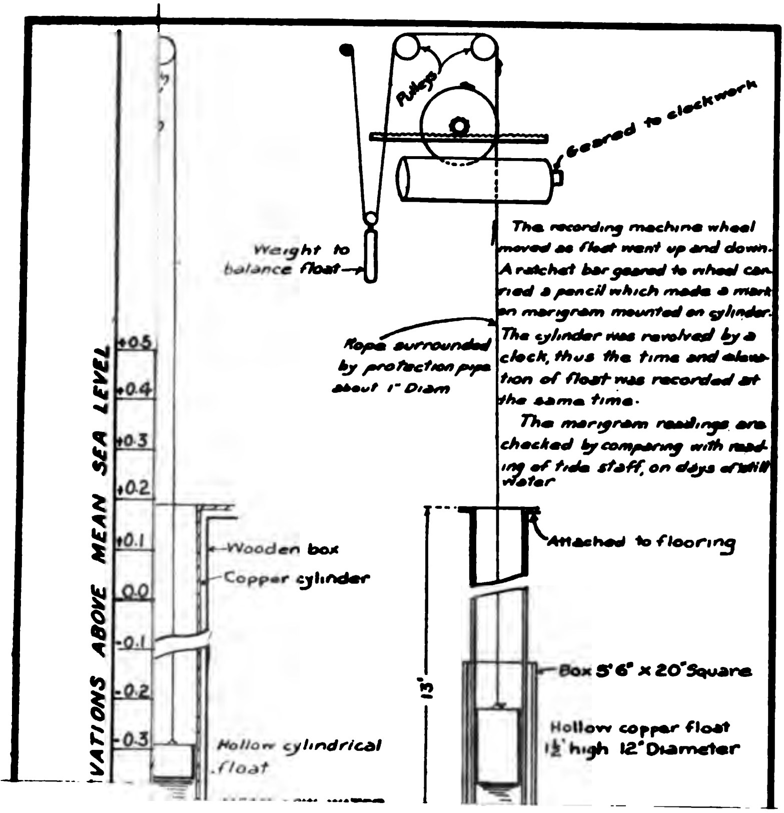
In the Reservoir Department, the method and equipment used was very similar to No. 3, being different in that instead of using a rod level for plumbing the rod, the rodman waved the rod to and fro from the instrument, the instrumentman setting the target at the smallest reading. On the levelling from Westkill to Prattsville, the rod was plumbed with a carpenter's level.

METHOD 4. THREE-WIRE LEVELLING.

This method was in use by Party No. 2 from April 10, 1906, to the end of levelling, and by Party No. 1 from July 1, 1906, to date. The outfit was Molitor rods and Berger level, with the exception of a week during December, 1907, when a Keuffel & Esser precise level was substituted for the Berger level. With this equipment the method of observing was substantially that used on the precise levelling of the United States Coast and Geodetic Surveys, with the following exceptions: First, the Government requires that on odd numbered stations the back sight be taken before the fore sight, and on even stations the fore sight before the back sight. Second, the temperature of the rod is noted by the Coast Survey for each sight and is used in the computations. The temperature was noted for most of the levelling, but was rarely used in the computations of the Board of Water Supply levels, as the correction from this source was small, the co-efficient of expansion being about four parts in a million per degree centigrade.

In levelling, all three wires are read on the rod sighted at, and the average of the three wires is taken for the mean rod reading. This practis has a three-fold object. First, a more accurate determination is obtained by averaging three readings than by one reading. Second, by noting the intervals between the middle and the extreme wires, a check is obtained on the wire readings. Third, the distance determination enables the observer to keep the lengths of sights nearly equal. The program for observing used by Party No. 1 was as follows: Rodman A being on the back sight, the instrument man and recorder went ahead to the station and set up the instrument. Meanwhile rodman B paced from the back sight to the instrument, then went ahead an equal number of paces, selecting a T. P. for the fore sight. The back rod was sighted at while the recorder, by a gentle pressure at the base of the level, kept the bubble

PLATE 68.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.



The recording machine wheel moved as float went up and down. A ratchet bar geared to wheel carried a pencil which made a mark on marigram mounted on cylinder. The cylinder was revolved by a clock, thus the time and elevation of float was recorded at the same time.

The marigram readings are checked by comparing with reading of tide staff, on days of still water

in the exact center. The hundredths and thousandths of each of the three wires was read aloud, then the recorder removed his hand from the instrument and repeated the figures read as he recorded them. The ft. and tenths were then read and set down at once in the note book, it being unnecessary to watch the bubble for the last reading. If the wire intervals checkt, rodman A was signalled to come ahead to act as fore rodman on the next set-up. Meanwhile the instrument was swung around for the fore-rod reading. The operation on the back sight was repeated on the fore sight. If these readings checkt the instrument was moved past the fore T. P. to a new station, where the whole operation was repeated. During warm and sunny weather the instrument was shaded by an umbrella. In very high winds, when it was impossible to keep the bubble steady and difficult to hold the rod plumb, work was abandoned.

A sample of notes with explanation of their use is shown on Plate 61. In this connection, it may be stated that on account of slight inequality in the spacing of the wires, the allowable differences between wire intervals varied with the length of sight. This difference was also slightly changeable with a change in the atmosferic conditions. It was found with Level No. 5499 that a difference of .006 ft. for 150-ft. sights and .008 to .012 ft. for 200 to 350-ft. sights is allowable, as the difference was found to be nearly the same in the same direction for both back and fore sights.

The length of sight taken depended on the conditions of the atmosphere, and was taken at a distance where the cross wire was steady and the graduations were distinct up to a maximum of 400 ft. It appeared that the longest sights with the three-wire level gave the better results for both accuracy and speed.

SPEED.

The results showing the speed of the work are tabulated in Table 1, page 164. The average time per day in the field varied from six to eight hours. A noteworthy feature of this tabulation is that the average number of miles per day represents about three-fourths of the actual speed of the levelling. Thus with no time lost to varying causes, the railroad levels were covered at a speed of nine to ten miles per day. On the primary circuits in Long Iland, seven to eight miles were covered frequently; on several occasions five miles of rough country work were covered per day in the levelling south of Hunter's Brook, whereas in Greater New York the party moved along while levelling at the rate of one mile an hour.

An examination of Tables 1 and 2 (page 164) indicates that the speed of the railroad work was equal to the results of that of the most experienced and efficient levelling organizations in this country. A very noteworthy feature is that the speed of the three-wire levels along roads is double that of the target levels, the costs being in inverse proportion.

The Southern Aqueduct speed is particularly noticeable, as it is practically double that of the Northern Aqueduct under the same conditions. This is due to the greater experience with the three-wire method and represents an actual speed while levelling with 20 to 25 stations per hour.

The speed of the target levelling (Method 3) averaged about 1.8 miles per day, and the average length of sight was about 125 ft. This speed is about the same as that of the U. S. Geological Survey, where the speed over rough mountainous country was 1.4 miles, and in flat country 2.5 miles per working day. (See *Transactions*, Am. Soc. C. E., Vol. XXXIX, pp. 348 to 350.)

RESULTS.

ACCURACY.

The circuit closures of the entire work are tabulated in Tables 4, 5, 6, 7 and 10 (pages 166 to 169) and also, where double lines were run, the closure of each single line and the average closure of the double line. The closure for each circuit is also shown on the locality maps. (Plates 53 to 59.)

A noteworthy feature of the closures is the small divergence of the duplicate lines, this being especially true of the 63-mile spur line from Ridgewood to Smith's Pond and Eastport. An examination in detail of this line shows the continuous divergence to be remarkably small, indicating, apparently, a very high degree of accuracy.

In addition to the test of the quality of the levels as indicated by the circuit closures, the instructions required that when the results of the two level runs between consecutiv bench marks differed by more than $.02 \sqrt{K}$ (where K is the distance between the bench marks in question) that section was to be rerun until the two results fell within the above limit. The total amount of lines rerun necessitated by this requirement was about 10 per cent.

The circuit closures of the work compare favorably with the precise levelling of other organizations, as shown in Table 9 (page 168), indicating the quality of the work to be equal to that of the most modern levelling.

In the tabulation of the double line circuit from Highlands to Cornwall there is but one in which the value of *C* for the mean of the two parties exceeds 0.020 ft. This one is from Highlands to Cornwall and has a length of 50 miles. An examination of the levelling between the primary bench marks upon which this circuit is based shows that there was a total discrepancy of 39.2 mm. or 0.128 ft. between the forward and backward line of the U. S. Coast and Geodetic Survey for 1903 (see Appendix 3, pp. 293-295). This discrepancy may partly account for the error of closure of the circuit, especially since the total divergence between the two parties was only 0.042 ft.

Of single-line levels, closures shown for target Method No. 3 appear to be slightly better than those of Method No. 2. Method No. 1 appears to be the least accurate. A comparison between the target and the 3-wire single lines appears to show little difference in the value of the circuit closures.

Another feature of the closures is that for about half the circuits, the single line shows as good closures as the double line. Also in nearly every case the error in the single line is within $.03 \sqrt{K}$, whereas in the double line in every case it is within $.02 \sqrt{K}$.

THE ADJUSTMENT OF CIRCUITS.

The method generally used for adjusting the levelling circuits is that described on pp. 613-616 of Johnson's Surveying, Edition of 1902. In brief, this considers the intersecting circuits as a number of geometrical polygons with sides common to each other. The polygon with the largest error is first adjusted, distributing the error as the square root of the length of the sides. The polygon with the next largest error of closure is then adjusted, and so on until the adjustment is completed. The adjustment of sides is final for each polygon, therefore, a new error must be figured for each adjacent circuit before its adjustment.

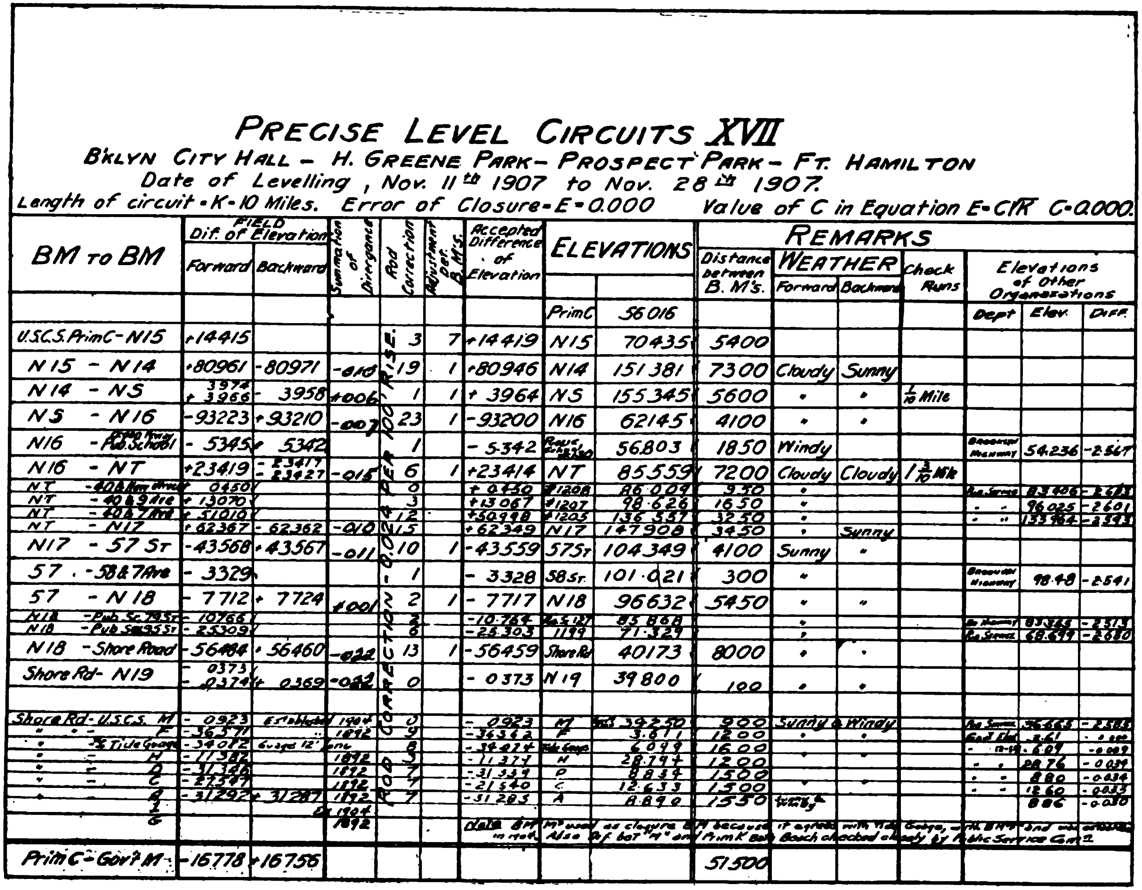
This method is partly based on the theory of error of the levelling survey, namely, that the error is proportional to the square root of the distance run. A modification of the above method was necessary in all of the levelling north of Fort Hamilton on account of the fixt elevations of the primary bench marks of the U. S. Coast and Geodetic Survey.

From Ashokan reservoir south to Hunter's Brook (6 miles from Peekskill), a systematic adjustment of all the levels was based, as far as possible, on the above described method. This fixt the elevation of a bench mark at Hunter's Brook, from which point southward to Fort Hamilton the adjustment is proportionally along the line between succeeding primary bench marks.

On spur lines an average between the forward and backward runs was used as a final difference of elevation. In this manner, the elevation of bench marks of the base line from Ridgewood along the condit to Smith's Pond and thence along the Montauk Division of the Long Iland R. R. to Westhampton, were fixt. A series of seven single-line circuits, tying into this base line and running thruout Suffolk County, were adjusted as described in Johnson's Surveying, with the exception that the circuits were computed in the order of their letters, as a strict adherence to the method resulted in throwing a large error into the circuits which the field figures showed to have the smallest errors of closures. These single line circuits were run to agree with an error $= .03 \sqrt{\text{distance in miles.}}$

In considering a method of adjustment, a feature of levelling to be noted is that short lines do not necessarily compensate error as the square root of the length of line, whereas long lines generally do. The writer therefore considers that a system of level polygons with sides 2 to 3 miles long should be adjusted proportional to the distance around the circuits. Where the sides of the polygons are longer, Johnson's surveying method should be used. Where levels are run between fixt elevations, the adjustment should be proportional to the distance. The writer further believes that the field party should make the adjustment, and that any method used should be modified to agree with the judgment of the leveller as to the liability of error in the different parts of the levels.

PLATE 64.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.



PRECISE LEVEL CIRCUITS XVII

B'KLYN CITY HALL – H. GREENE PARK – PROSPECT PARK – FT. HAMILTON

Date of Levelling, Nov. 11th 1907 to Nov. 28th 1907.

Length of circuit = K = 10 Miles. Error of Closure = E = 0.000 Value of C in Equation E = C√K C = 0.000.

BM to BM	Field Dif. of Elevation Forward	Field Dif. of Elevation Backward	Summation of Divergence	Rod Correction	Adjustment per B.M.'s	Accepted Difference of Elevation	Elevations		Remarks: Distance between B.M's.	Weather Forward	Weather Backward	Check Runs	Elevations of Other Organizations: Dept	Elev.	Diff.
							PrimC	56016							
U.S.C.S. PrimC – N15	+14415			3	7	+14419	N15	70435	5400						
N15 – N14	+80961	–80971	–010	19	1	+80946	N14	151381	7300	Cloudy	Sunny				
N14 – NS	3974 +3966	–3958	+006	1	1	+3964	NS	155345	5600	"	"	1/10 Mile			
NS – N16	–93223	+93210	–007	23	1	–93200	N16	62145	4100	"	"				
N16 – [illegible] Pub. School	–5345	+5342		1		–5342	[illegible]	56803	1850	Windy			Brooklyn Highway	54.236	–2.567
N16 – NT	+23419	–23419 –23427	–015	6	1	+23414	NT	85559	7200	Cloudy	Cloudy	1 3/10 Mile			
NT – 40th & [illegible]	+0450			0		+0450	#1208	86.009	950	"			Pub. Service	83.406	–2.603
NT – 40 & 9 Ave	+13070			3		+13067	#1207	98.626	1650	"			" "	96.025	–2.601
NT – 40 & 7 Ave	+51010			12		+50998	#1205	136.557	3250	"			" "	133.964	–2.593
NT – N17	+62367	–62362	–010	15		+62349	N17	147908	3450	"	Sunny				
N17 – 57 St	–43568	+43567	–011	10	1	–43559	57 St	104349	4100	Sunny	"				
57 – 58 & 7 Ave	–3329			1		–3328	58 St.	101.021	300	"			Brooklyn Highway	98.48	–2.541
57 – N18	–7712	+7724	+001	2	1	–7717	N18	96632	5450	"	"				
N18 – Pub Sc 79 St	–10766			2		–10.764	[illegible]	85.868		"			[illegible]	83.355	–2.513
N18 – Pub Sc 95 St	–25309			6		–25.303	1199	71.329		"			Pub. Service	68.649	–2.680
N18 – Shore Road	–56484	+56460	–022	13	1	–56459	Shore Rd	40173	8000	"	"				
Shore Rd – N19	–0373 –0374	+0369	–022	0		–0373	N19	39800	100	"	"				
Shore Rd – U.S.C.S. M	–0923	Established	1904	0		–0923	M	[illegible] 39.250	900	Sunny & Windy			Pub. Service	36.665	–2.585
" " – F	–36371	"	1892	9		–36362	F	3.611	1200	"	"		Gov't Elev.	3.61	[illegible]
" " – Tide Gauge	–34082	Gauge 12'	one	8		–34074	Tide Gauge	6.049	1600	"	"		" 12-19	6.04	–0.009
" – H	–11382		1892	5		–11377	H	28.794	1200	"	"		" "	28.76	–0.034
" – D	–31346		1892	7		–31339	D	8.834	1500				" "	8.80	–0.034
" – C	–21547		1892	7		–21540	C	12.633	1500	"	"		" "	12.60	–0.033
" – A	–31292	+31287	1892	7		–31285	A	8.890	1550	Sunny & Windy				8.86	–0.030
I			1904												
G			1892												
						Note BM M° used as closure BM because it agrees with Tide Gauge, with BM I and was established in 1904. Also Dif bet "M" and Prim K both checked closely by Public Service Com.									
PrimC – Gov't M	–16778	+16756							51500						

ROD CORRECTION – 0.024 PER 100' RISE

SAMPLE OF ADJUSTMENT CALCULATIONS.

The computations of the adjustment were made on regular forms showing the field figures, the rod corrections, the divergence of the level lines, the adjustment between bench marks, the accepted elevations and the distances between bench marks, and also the weather conditions of the runs. A sample of the computations is shown on Plate 68.

LEVELS OF OTHER ORGANIZATIONS.

On Plate 69 is tabulated the origin of various datums and a list of bench marks showing by difference the relativ accuracy of the work of different city departments. Comparison is directed to the datum planes differences tabulated on p. 214 of the *Procedings* of the Municipal Engineers for 1905.

North of Greater New York the bench marks of the Geological Survey and the Burr-Hering-Freeman Commission surveys are met with. In Greater New York, the agreement of the levels of the various city departments with our work is particularly noticeable. In some instances, such as the Brooklyn Department of Water Supply and the Public Service Commission elevations, abrupt changes in the accuracy were noted. In every case the Board of Water Supply level line is checkt at the point of change by the levels of other departments.

Eastward from Ridgewood, the bench marks of the Brooklyn Department of Water Supply are met with. These show good agreement with our work. In Long Iland the Burr-Hering-Freeman Commission and the Geological Survey bench marks are met, with the results as tabulated.

PROPOSED DATUM FOR NEW YORK CITY.

The number of different datums in use by the different departments of New York City is incomprehensible from a topographical engineer's point of view. The topography of a street of New York City may have four or five different elevations, neither of which is of greater legality than the other. For instance: The Department of Bridges may file a map showing the elevations above the Coast and Geodetic Survey datum, while the maps of the Brooklyn Highway Department, the Department of Water Supply, the Brooklyn Sewer Department, the Public Service Commission and the Dock Department will show a different hight for the same street.

From a legal point of view, what is the hight? Neither department can claim its datum as legal since it is not so recognized by the others. The mean high-water datum is presumed to be convenient for drainage and sewer studies, and low water is convenient for navigation studies, but the fact that mean low or mean high water varies two feet from mean sea level at the east end of Long Iland, and seven feet at City Iland, makes either as a datum at one place meaningless at the other. On the other hand, mean sea level, as fixt by the U. S. Coast and Geodetic Survey, is the same for all places, and may be said to be legally recognized by the U. S. Government, since the Bridge Department is required to show on their maps that all new bridges are a certain number of feet above the Coast and Geodetic Survey datum. Again, the state of New York requires that the Board of Water Supply shall not build the Ashokan Dam over 600 ft. above the U. S. Coast and Geodetic Survey datum.

It is clear then, that no legal datum exists in New York City, and also that it is a simple engineering proposition that a datum to which all the departments will refer their work should be agreed upon.

The tabulation on Plate 69, shows that the levels of the Coast and Geodetic Survey and those of the various city departments agree with each other. It therefore appears that levelling data sufficient for the framing of a common datum is on record. It would also appear that a committee of the society consisting of one engineer from each department, should be appointed to secure the consent of each department to the following:

FIRST.—The adoption of a list of primary bench marks, said list having been made up by the Committee above mentioned.

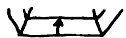
SECOND.—To decide whether it is advisable to establish a common datum, and if not, to have each department agree to accept a certain difference from the datum of the primary bench marks, this difference to be shown on all future maps.

The writer personally visited the engineering heads of most of the city departments, and a synopsis of opinions showed:

(*a*) Every department favored the first recommendation.

(*b*) The opinions for and against changing to a common datum were divided.

PLATE 65.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.

			U.S. Coast and Geodetic Survey. BM's used as Primary BM's by Board of Water Supply.
Location	Designation of Bench Mark	Elevation	Description.
Rhinecliff	Iyyy	13.011	Top of fish plate bolt in rock at rear of R.R. Station, opposite S. E. end.
Staatsburg	R.R. DeWitt	24.078	At mile post "N.Y. 83 miles," first cut S. of R.R. Sta. Top of bolt in large rock 2' high on east side of track just east of the gutter.
Hyde Park	R.R. 161	7.463	Top of fish plate bolt in flat rock in gutter on east side of track, 210 ft. N. of Bridge #223
Poughkeepsie	If'	20.300	2 miles N. of Pokeepsie R.R. Sta. Hole drilled in in rock 4"x6"x13" high, near path, 8' W. of westerly rail 16' from S.E. cor. of coal shed at State Hosp. Pump. Sta
"	HI.	31.683	1¼ M. S. of Pokeepsie R.R. Sta. Bottom of a hole cut in stone, 2 rails S. of Tower Nº 57, 40' E of E. rail, 12 E. of wire fence on large flat rock 1' high.
Camelot	GI.	5.787	Bottom of square hole cut in stone on N. side of low rocky point of land, 6 ft. from river bank, 4' above high water, 60' W. of W. rail, 12' N. of prolongation of N. side of R.R. Station
New Hamburg	Ii'	14.549	Hole drilled in irregular shaped rock at West edge of gutter on West side of track, 120' N. of R.R. Station.
Cold Spring	V09	14.035	Top of fish plate bolt near stand pipe on E. side of track, N. of R.R. Station, just south of rock cut.
Garrison	RR. 99	20.636	Top of fish plate bolt on east side of track, 680 ft. S. of south portal of R.R. tunnel.
Peekskill	VO	10.541	On stone sill of door to waiting room R.R. Station. Cross cut on S.W. corner of sill (Rod held on smooth stone in crotch of cross nearest edge of sill.
Tarrytown	Y	8.565	Is about ½ M. S. of Tarrytown about 100 yds N. of B. M. "X"; 198' S of Center of culvert #63 on the E. side of the track, 6' from the E. rail and 8' below the top of the rail; about opposite the center of the mound of earth left standing on the W.S. of tracks on a horizontal ledge of very hard stone projecting from the bottom of the face of the cut. U □ S B M
"	Z	20.503	On the first Highway bridge across tracks N. of R.R. Sta., on the S. end of the E. abutment, 4' above ground and 12" from the face next the tracks. ⊕ ← Intersection lines copper bolt
Dobb's Ferry	T.	13.873	About 150' S. of R.R. Sta. about 75' N of Center of Highway Bridge across the tracks on the retaining wall on E. side of the tracks in the capstone of the "lowest" step" about 18" from N. end and 6" from the end of the next highest step. U □ S B M — Bottom square hole
L. I. City	Prim. B	7.942	+ cut in N.W. Cor. of vestibule of Miller's L. I. City Hotel, Cor. Borden Ave & Front St Entrance to building is at S.W. Cor. B M. is about 1" from the outer edge of sill and about 4" from where the brick wall ends.
Brooklyn	Prim. C	56.016	Cut on water table, Hall of Records, 5½' S. of Cor. of Fulton St (Court Square) head of arrow at top of slope is B.M. Letters and arrow cut in by B.W.S. 
Fort Hamilton	M.	39.250	Establised from Tide Gauge in 1904, is a horizontal cut in a brass bolt set in the concrete wall, at N.W. Cor. of fortification. It is at the intersection of Shore Road and Fort Hamilton Ave.

Character of Bench Marks.

The bench marks were selected with a view to their permanence and ease of description. The various types met in the field are shown on Plate No. 60. The standard pipe casing, or bolt bench mark, has been set at distances varying from ¼ mile to 1 mile, over the entire distance from Ashokan Reservoir to Ridgewood, in Brooklyn. Intermediate marks are mostly trees, cuts on masonry or ledge. In Greater New York, permits to set bench marks were received from the Park Commissioners, from Calvary and Mt. Olivet Cemeteries, New York, New Haven & Hartford R. R., and from the Fort Wadsworth authorities.

In Long Iland, easterly from Ridgewood, the bench marks were selected in the field, and are mostly on trees, concrete signal posts and masonry bridges. It was the intention to set pipe casing bench marks at various parts of the iland at a later date, and thus make permanent the levelling survey. A list of bench marks from Schoharie County to the end of Long Iland is shown on Plates Nos. 66, 67 and 68.

It is to be particularly noted that the locations for all bench marks were carefully selected, time being taken to establish a clean distinct mark and one of as great permanence as could be secured in the vicinity. A great many of the bench marks are on large trees, certain not to vary much for at least five or ten years.

CONCLUSIONS.

Errors of Levelling.

The close observation of the various errors of levelling show that the three main requirements for practical accurate levelling are:

(1) An approach to simultaneous levelling; that is, the lapse of a minimum time between back and fore sights.

(2) Care in performing work, such as testing rods and instruments.

(3) The elimination of possible systematic errors.

(1) The first is by far the most important, for refraction and temperature changes take place rapidly at certain times of the day, especially in a frequent change from a bright to a dull sun. At times it was found that a rod reading at a distance of 200 to 300 ft. would change .004 to .005 ft. in a short interval of time. As-

suming the rods to be clearly seen, the length of allowable sight appears to depend partly on the time between sights. Thus with 400-ft. distances and a lapse of about 10 to 15 sec. between sights, 3-wire level work will give as good and possibly better results than the target method with sights of 200 ft. or less. A minimum of time between sights insures that the bubble will be under the same conditions for both sights, and that the temperature of the instrument will probably not change unequally in the meanwhile.

(2) Keep the back and fore sights equal and test the instrument frequently to determin the error of collimation for 100 ft. Pacing is sufficiently good for equalizing sights, altho the actual measurement, as with a 3-wire level, shows whether the sights are taken equal or otherwise. Unequal sights may cause the largest error of a levelling survey, especially where an instrument is considerably out of adjustment. Carelessness in not having the bubble in the exact center is a source of error, and in not shading the instrument in hot weather, when the bubble shows a tendency to stick to the tube. Carelessness in not selecting clean turning points is a source of considerable error and requires a reliable rodman. To eliminate possibility of error from this source, turning point pins should always be used. A plumb rod is a necessity for accurate work. By attaching a bubble to the rod, the liability of its being out of plumb is practically eliminated. In hilly country the rods should be frequently compared with a 10-ft. length of tape, kept for the purpose of detecting changes in its length. The adjustment of the level should be tested frequently. It will be found that testing twice each week is generally sufficient.

(3) Possible systematic errors of levelling may be due to unequal expansion between the telescope and the bubble tube, especially when the levelling is in the direction of the sun, to the settling of turning point pins or the rising or settling of the instrument, or to a systematic error due to the direction of the wind. These errors are discust on pp. 877 to 885 of Appendix 8, Coast and Geodetic Survey Report for 1899, with a result that shows them to be of very small magnitude, the temperature changes being larger than the others. Again a systematic error may be due to settlement in frosty ground. It is, however, certain that any or all of these errors may exist at any position of a level line, and to eliminate these possible errors, it is

safe to run a line forward in one direction, and relevel it in the backward direction. If there is any systematic error in one direction it will be increast by the backward run creating a large divergence of the level lines. It has been the experience of the writer, however, that a wide divergence of run is likely to be met, when some little time elapses between back and fore sights. In this connection, it may be stated that the observation of a rod or the setting of a bisecting target is a compensating error which does not enter much into a consideration of the errors of levelling.

Discussion of Outfits.

From observation of the merits of a dumpy, wye and Coast and Geodetic Survey type of level, it seems that with correct handling the fault of an instrument is in not keeping its adjustment, and that unstable parts constitute the main defects of the ordinary level for accurate work. With equally sensitiv bubbles and snug capstan screws and nuts, there is no advantage in point of accuracy for either type of level, for sights up to 400 ft., except that a dumpy is smaller and of less parts for the same power of instrument, and is therefore preferable on account of convenience of handling and less likelihood of getting out of adjustment. For railroad work where sights of 400 to 500 ft. can be taken, the Coast and Geodetic Survey level is justifiable mainly on account of the greater optical power of the instrument. It is fairly certain that an ordinary dumpy level with equal optical qualities and equally sensitiv bubble would be as good. This was proved when a Coast and Geodetic Survey level was used on the backward run of about 10 miles of levelling, which was previously run with the ordinary dumpy level. The result showed a continuous almost identical agreement between the runs, proving conclusivly that one level was as good as the other for accuracy.

For the 300 to 400-ft. sights of the above run, the rods were seen with almost equal clearness with both levels. It would therefore appear that the 13-seconds bubble of the ordinary level was as good as the 8-seconds bubble of the Coast and Geodetic Survey level. This appears to agree with the experiments as to error of centering bubbles of varying sensitivness (p. 41, *Transactions*, Am. Soc. C. E., Vol. XLV) where it is shown that the error of centering a 2.7-second bubble was an angle of .135 sec., whereas a 9-sec. bubble error of centering was .27 sec. of angle. The difference in rod reading between these two for a 300-ft. sight is .0002 ft., which is a negligible quantity.

The single stick rods of the Molitor type, with bubble attacht as used, have the great merit of being seen clearly, in good weather, with an ordinary level at a distance of 350 to 400 ft. They are reinforced against warping, and in these respects are much superior to the jointed New York and Philadelphia rods, especially since in many jointed rods an error of .001 or more exists at the joint.

The pins used should be those shown on Plate 60; the gravity pin for road work, and the other for cross country levelling.

INSTRUCTIONS FOR LEVELLING.

The method to be used should be substantially that described as 3-wire levelling, of which the essential features necessary to secure the required degree of accuracy with the greatest rapidity and economy are:

(1) The limit of discrepancy allowable between duplicate runs should be $.02 \sqrt{\text{distance in miles}}$. For a circuit the equivalent limit of error of closure should be $.014$ ft. $\sqrt{K}$, where K is the length in one direction of the circuit in miles. For single line levels, the allowable error of circuit closure should be $.025 \sqrt{K}$.

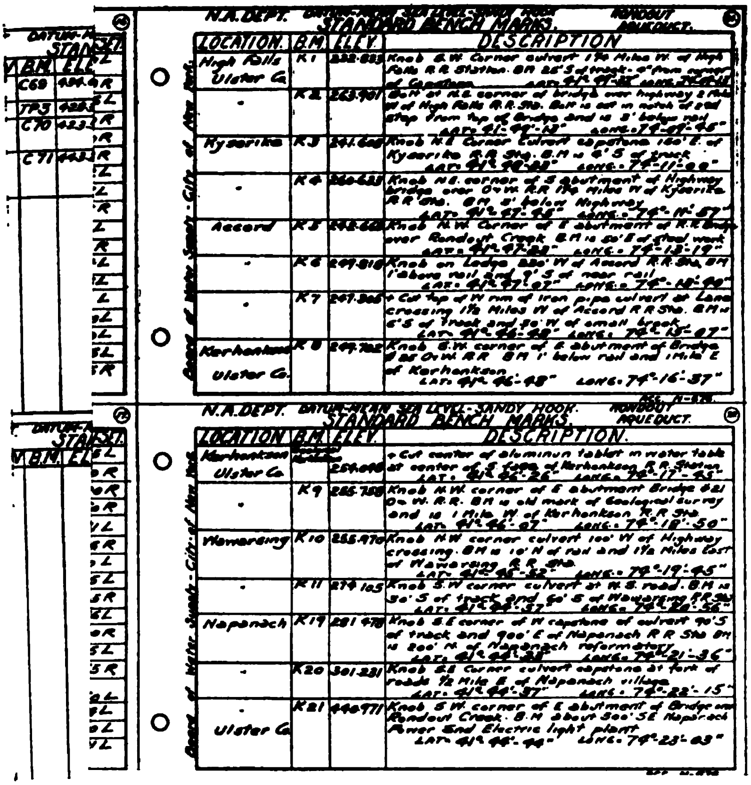
(2) The use of an instrument of the dumpy type similar to the Berger 3-wire level for road or hill work. For railroad work, for long distances where sights over 400 ft. can be continuously taken, an instrument similar in design to the precise level of the U. S. Coast and Geodetic Survey might be used, altho it seems that an ordinary dumpy of the same optical power, fitted with an 8-sec. bubble, would be preferable.

(3) Self-reading rods with attacht bubble as used in Method 4.

(4) Turning-point pins.

(5) Sights should be equal, and as nearly simultaneous as possible; that is, a minimum of time between the back and the fore sight. The length of the sight should be limited to a distance at which the graduations are distinct and the wires steady, up to a maximum of 450 ft.

PLATE 66.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.



N.A. DEPT. DATUM-MEAN SEA LEVEL-SANDY HOOK. RONDOUT AQUEDUCT.

STANDARD BENCH MARKS.

Board of Water Supply - City of New York.

LOCATION.	B.M.	ELEV.	DESCRIPTION
High Falls Ulster Co.	K1	232.885	Knob S.W. Corner culvert 1½ Miles W. of High Falls R.R. Station. BM 25' S of track - 4" from corner of capstone. LAT. 41° 49'-35" LONG. 74° [illegible]
·	K2	263.901	Bolt at N.E. corner of bridge over highway 2 Miles W of High Falls R.R. Sta. Bolt is set in notch of 2nd step from top of Bridge and is 3' below rail. LAT. 41° 49'-12" LONG. 74°-09'-45"
Kyserike	K3	241.649	Knob N.E. Corner Culvert capstone 150' E. of Kyserike R.R. Sta. B.M is 4' S of track. LAT. 41° 48'-22" LONG. 74°-11'-00"
·	K4	260.635	Knob N.E. corner of S abutment of Highway bridge over O.&W. R.R 1½ Miles W of Kyserike R.R. Sta. BM 5' below Highway. LAT. 41° 47'-45" LONG. 74°-11'-57"
Accord	K5	242.662	Knob N.W. Corner of E abutment of R.R. Bridge over Rondout Creek. BM is 50' E of steel work. LAT. 41° 47'-28" LONG. 74°-13'-19"
·	K6	249.816	Knob on Ledge 250' W of Accord R.R. Sta. BM 1' above rail and 9' S of near rail. LAT. 41° 47'-07" LONG. 74°-14'-40"
·	K7	247.305	+ Cut top of W rim of iron pipe culvert at Lane crossing 1½ Miles W of Accord R.R. Sta. BM is 6' S of track and 50' W of small brook. LAT. 41° 46'-48" LONG. 74°-15'-07"
Kerhonkson Ulster Co.	K8	249.702	Knob S.W. corner of E abutment of Bridge # 25 O.&W. R.R. BM 1' below rail and 1 Mile E of Kerhonkson. LAT. 41° 46'-48" LONG. 74°-16'-37"

N.A. DEPT. DATUM-MEAN SEA LEVEL-SANDY HOOK. RONDOUT AQUEDUCT.

STANDARD BENCH MARKS.

Board of Water Supply - City of New York.

LOCATION	B.M.	ELEV.	DESCRIPTION.
Kerhonkson Ulster Co.	[illegible]	254.046	+ Cut center of aluminum tablet in water table at center of S face of Kerhonkson R.R. Station. LAT. 41° 46'-26" LONG. 74°-17'-55"
·	K9	255.755	Knob N.W. corner of E abutment Bridge #21 O.&W. R.R. BM is old mark of Geological Survey and is 1 Mile W. of Kerhonkson R.R. Sta. LAT. 41° 46'-07" LONG. 74°-18'-50"
Wawarsing	K10	255.970	Knob N.W. corner culvert 100' W of Highway crossing. BM is 10' N of rail and 1½ Miles East of Wawarsing R.R. Sta. LAT. 41° 45'-52" LONG. 74°-19'-45"
·	K11	274.105	Knob S.W. corner culvert at N.S. road. B.M is 50' S of track and 60' S of Wawarsing R.R. Sta. LAT. 41° 44'-57" LONG. 74°-20'-56"
Napanoch	K19	281.478	Knob S.E corner of W capstone of culvert 90' S of track and 900' E of Napanoch R R Sta. BM is 200' N of Napanoch reformatory. LAT. 41° 44'-38" LONG. 74°-21'-36"
·	K20	301.231	Knob S.E Corner culvert capstone at fork of roads ½ Mile E of Napanoch village. LAT. 41° 44'-37" LONG. 74°-22'-15"
· Ulster Co.	K21	446.971	Knob S.W. corner of E abutment of Bridge over Rondout Creek. B.M about 500' SE Napanoch Power and Electric light plant. LAT. 41° 44'-44" LONG. 74°-23'-03"

(6) Rods should be compared with steel tape daily to detect any change in length. Instruments should be tested for adjustment at least twice a week. A record should be required in notes for each of the above tests.

(7) There should be two rodmen and one notekeeper for each instrument. The sequence of rods should be as described.

(8) The use of an umbrella to shade the instrument from the sun in warm and sunny weather. Work should be discontinued in high winds when the wires appear to be unsteady and move on the rod.

(9) Each line should be levelled independently at least twice; once in a forward and once in a backward direction.

(10) A detailed record of the speed and cost of work should be kept.

COMPARISON OF TARGET AND 3-WIRE LEVELLING.

ACCURACY.

In concluding this paper attention is called to the merits of the 3-wire levelling in comparison with target levelling.

The single-wire reading on a self-reading rod without any rod check is conceded by many engineers to give speedy results with as great accuracy as obtained by the use of target rods. In the Public Service Commission levels in New York City, self-reading rods and a single-wire level are used. Turning points are located every block and are used on both the forward and backward runs. The probability of error with the single-wire readings on a self-reading rod is so great that the target rod is still adhered to. The 3-wire level is the single-wire level with the addition of two extra wires that give the desired check on the results, and at the same time give greater accuracy by thus securing three independent readings of the rod.

With the 3-wire level methods the rod is a fixt target, and the cross hairs move with the bubble whereas in the target method the target and the cross hairs both move. The wire interval check eliminates the possibility of large errors in rod reading. The wire interval check gives absolute assurance of the readings, whereas in target levelling a careless or uncheckt reading of the rod, the slipping of the target before reading, etc., will introduce errors often necessitating the repetition of long runs. A rod with a bubble attacht is rarely out of plumb, whereas in many systems of target levelling, rod levels are not used. The 3-wire method is especially adapted to rapid levelling of long lines without frequent checks.

The short time interval between the + and the — sights insures with the 3-wire method the same atmosphere and the same condition of bubble for each of the sights at any set-up. In target levelling, greater time elapses between the target settings. With rapid refraction changes, and the effect of the sun on the length of the bubble, this condition becomes of prime importance, and is probably the main reason why target settings should have shorter sights.

In the 3-wire level notes, the distance along the line of all turning points and set-ups are known, and these points may be readily located. The record also shows the total distance of each of the fore sights and back sights, and enables them to be constantly balanced.

In 1899 a committee of levelling experts appointed by the U. S. Coast and Geodetic Survey decided that the 3-wire method is far superior to any target rod method of levelling for securing accuracy and speed, and on page 445 of the Coast and Geodetic Survey report of 1899, in the examination of levels as indicated by circuit closures, Mr. Hayford shows that the target rod methods generally showed closures greater than $\sqrt{M}$ times a constant indicating the presence of accumulative error. The 3-wire level closures generally closed within the $\sqrt{M}$ times the constant. This would indicate that 3-wire levelling would compensate errors of levelling more in accordance with theory than the target rod methods.

SPEED.

The speed of levelling is generally determined by the character of the country, whether flat or hilly, the conditions of the atmosphere and the speed of observation.

In flat country with 300 to 350-ft. sights, allowing 5 minutes per hour for cutting in bench marks, eleven stations per hour were occupied with the 3-wire level, giving a speed of 1.4 miles per hour. With 200-ft. sights, fourteen stations per hour were occupied giving in both cases a speed exceeding 1 mile per hour.

In general the shorter the sights taken the greater the number of stations occupied per hour. For average 100-ft. sights, twenty to twenty-five stations per hour were occupied, while on the steep continuous grade of Breakneck Valley Road, thirty-two stations, dropping 270 ft. in elevation, were accomplisht in the hour, being less than 2 minutes per station. On several occasions one hundred and fifty stations were occupied within a 6½-hr. day, where the average sight was about 100 ft.

In this connection the speed of observation may be emphasized when we consider that the speed of the party when walking between points is 3 miles per hour. After the fore sight is taken, the fore rodman waits at his turning point while the instrument man is walking to the next station. The time of levelling may be summarized as follows for a speed of 1.4 miles per hour:

Cutting in bench mark................	5	minutes.
Walking 1.4 miles at 3 miles an hour....	28	“
Time each rodman waits at turning point	14	“
Time selecting turning points, levelling up and taking sights....................	13	“
	60	“

This tabulation shows clearly that some means of quicker transit between turning points would greatly increase the speed. On one occasion by walking fast between turning points on check work, the actual speed of levelling was 2 miles per hour. On April 13th, 1908, along a railroad, 13 miles was levelled in 7 hours and 50 minutes, the average sight being 264 ft., and the number of set-ups 131, an average of seventeen stations per hour. The figures obtained checkt the other runs. A speed of 6 miles an hour when walking between turning points would give a levelling speed of 2½ miles an hour. On the U. S. Coast and Geodetic Survey work, by the use of velocipede cars for transit, speeds of 2¼ miles an hour have been maintained.

With target levelling and one set-up between turning points, it was found in the Northern Aqueduct Department that with an average 100-ft. sight, the number of stations occupied per hour varied from 8 to 10. This contrasts with twenty stations per hour of the 3-wire level.

With the target rods and a 3-man party in the Northern Aqueduct Department, the speed, with average 100-ft. sights, rarely exceded 1½ miles per day, whereas, with the same average sight, both of the level parties covered at least 3 miles per day with the 3-wire level.

In the description of the Geological Survey target levelling 2-man party, with one set-up between turning points, the average speed was 1.4 miles per working day, over rough mountainous country, and in flat country 2.5 miles per working day. (See *Transactions*, Am. Soc. C. E., Vol. XXXIX, pp. 349-350.) On the assumption of a 6-hr. day this is less than ½ mile per hour.

On the assumption of ½ mile per hour for flat country target levelling, the time per hour may be subdivided as follows:

Time to walk ½ mile................ = 10 minutes.
Cutting in bench mark.............. = 5 "
Time rear rodman stays at turning points while inst. is carried to next station. = 5 "
Time of selecting turning points, levelling up and setting targets........ = 40 "
—
60 "

As in flat country the length of sights permissible varies from 200 to 300 ft. for work of precision. This indicates that the number of stations occupied per hour would be from five to six, whereas, with a 3-wire level, eleven stations, with longer sights, could be occupied in the hour. Attention is also called to:

The time of actual levelling per hour with 3-wire level.................. = 13 minutes.
The time of actual levelling per hour with target rod method............ = 40 "

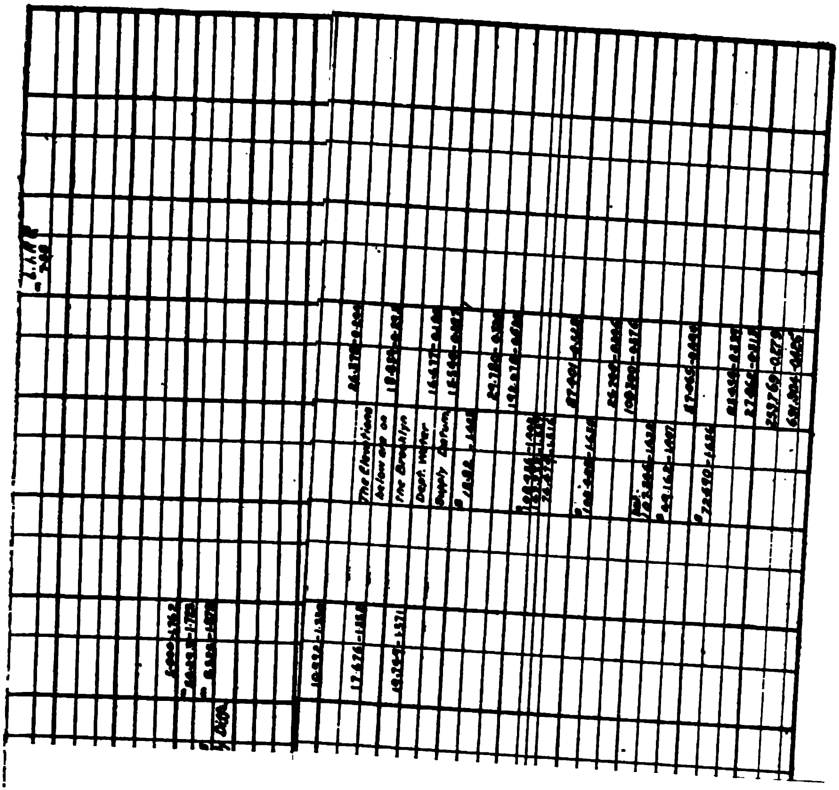
The essential difference in speeds of the methods is due to the longer sights, of the 3-wire levels, and the slow operations in handling the target rods.

Cost Comparison.

The cost is in direct proportion to the speed, and in deciding which system of levels to use, the speed under equal conditions should be considered:

PLATE 69.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
GOODMAN ON BENCH LEVELS
AND NEW YORK CITY DATUMS.


The Elevations below are on the Brooklyn Dept. Water Supply Datum

The bubble may be constantly shifting, and should always be watcht while the sight is taken. For very accurate levelling this makes a 4-man party necessary for 3-wire work (because of the long sight), and desirable for the target-rod method of levelling, altho the shorter sights used with the targets may allow the use of a 3-man party, consisting of two rodmen and the observer. It would appear from the evidence in Table 1 that the speed of the 3-wire levelling is about double that of the target-rod methods under the same conditions.

For common target levels (which are of less importance than bench levels) it is usual to have 3-man and 2-man parties. For the same length of sights, 3-wire level parties would certainly be much more rapid. On several occasions with the 3-wire levels, the writer found that the speed of a 3-man party was 80% of a 4-man party, increasing to 90% as hill work was encountered. The operation with 3 men was as follows: The leveller kept the notes and the fore rodman watcht the bubble as the rear rod was sighted. Then the fore rodman moved forward and the rear rodman came ahead to watch the bubble for the fore sight. This enabled as long sights to be taken as with a 4-man party. The attachment of a mirror to reflect the bubble to the observer's eyes would enable the maximum lengths of sights to be taken with the 3-wire levels 3-man or 2-man parties, resulting in much more progress than is possible with target methods.

In conclusion special attention is called to the machine like methods of 3-wire level. The duties of the rodman are simple and automatic; the position of rod is fixt by the bubble; the wire readings are mechanical; the check of the wire intervals on the correct reading of the wires, and the record of the equality of back and fore sights liken the system to a machine with a safety device for detecting observer's and rodman's error.

An examination of the above comparison shows the greater accuracy, increast speed at less cost and less chance of error of the 3-wire method, as compared with the target-rod levelling, and the writer strongly advocates the use of the 3-wire level and single stick rods for any differential or bench-level work.

TABLE No. 1.—SUMMARY OF SPEED—BOARD OF WATER SUPPLY LEVELS.

Location.	Character of ground.	Average length of sight, in feet.	Total field working days.	Distance in Miles. Total.	Distance in Miles. Per day.	Remarks.
Long Iland........	Railroad.	272	17	114.6	6.7	3-wire levels.
" "	Largely roads.	225	28	150.0	5.4	" "
New York City..	Paved streets.	179	31½	135.8	4.3	" "
0 to 40 miles north of N. Y. City....	50% roads, 50% cross-country	95	31	104.2	3.4	" "
40 to 90 miles north of N. Y. City....	Roads.	About 200	......	372.0	4.0	" "
40 to 90 miles north of N. Y. City....	Cross country	90	......		1½ to 2	" "
40 to 90 miles north of N. Y. City....	40% roads, 60% railroad.	215	7½*	54.0	7.2	" "
40 to 90 miles north of N. Y. City....	Roads.	100 to 125	......	215.0	About 1.8	Target levels.

Hours work per day, 6 to 8; average about 7 hours.

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* On April 13, 1908, party leveled 13 miles along railroad (walking) in 7 hours 50 minutes; the average sight was 264 feet; set-ups, 131; stations per hour, 17; average speed per hour, 1.7 miles; at times speed was 2 miles an hour.

A notable feature of above levels was that the speed per day was one-third more than average when no delays were met with (delays were selecting bench marks, checking notes, less hours work account long drives to hotel).

TABLE No. 2.—SPEED AND COST—MISCELLANEOUS ORGANIZATIONS.

Organization.	Character of ground.	Average length of sight.	Single miles per day.	Cost per single mile.	Reference.	Remarks.
U. S. C. and G. Survey after 1899............	Railroad	..	7.0	$4.50	Report for 1908, App. 8	3-wire levels.
U. S. C. and G. Survey in 1899...............	......	....	4.5	9.33	*Trans.*, Am. Soc. C. E., pp. 174, 175, Vol. XLV.	" ".
U. S. C. and G. Survey prior to 1899.........	......	....	2.0	15.60	*Trans.*, Am. Soc. C. E., p. 377, Vol. XXXIX.	Target levels.
U. S. Engineer Corps..	......	....	2.8	23.41	*Trans.*, Am. Soc. C. E., p. 377, Vol. XXXIX.	....
U. S. Geological Survey..................	......	....	5.0	5.50	*Trans.*, Am. Soc. C. E., pp. 370, 377, Vol. XXXIX.	Target rods used.
N. Y. State Barge Canal...............	......	....	3.4	13.00	Report of Wm. B. Landreth, 1902.	....
Mississippi River Com.	......	....	3.05	15.25	*Trans.*, Am. Soc. C. E.. pp. 178, 179, Vol. XLV	....
U. S. Board of Engineers on Deep Waterways..........	Roads	162	2.7	......	*Trans.*, Am. Soc. C. E., p. 118, Vol. XLV.	3-wire levels.
Los Angeles aqueduct.	....	....	5.2	......	*Eng. News*, Sept. 17, 1908	3-wire levels.

TABLE No. 3.—SAMPLE OF NOTES ON RIVER CROSSINGS.

Location: Rhinecliff—Kingston Pt. Dist. = 1.0 mile.

Date: Dec. 16, 1905. Cloudy, light wind.

PARTY No. 1.				**PARTY No. 2.**			
Inst. on east side of river.		**Inst. on west side of river.**		**Inst. on west side of river.**		**Inst. on east side of river.**	
+ *S.*	− *S.*	+ *S.*	− *S.*	+ *S.*	− *S.*	+ *S.*	− *S.*
4.818	5.672	4.057	4.842	3.680	4.229	4.572	5.518
....	5.670	4.045	....	3.679	....	....	5.521
....	5.702	4.065	....	3.654	....	....	5.522
....	5.677	4.049	....	3.658	....	....	5.544
....	5.710	4.071	....	3.694	....	....	5.527
....	5.728	4.052	....	3.708	....	4.572	5.530
....	5.736	4.033	4.842	3.678	4.229	....	....
4.818	5.714	....	....	....	....	....	....

Date: Dec. 18, 1905. Clear, no wind.

5.098	5.774	4.049	4.793	3.766	4.607	4.572	5.551
....	5.754	4.049	....	3.732	....	....	5.565
....	5.761	4.018	....	3.756	....	....	5.541
....	5.762	4.003	....	3.742	....	....	5.543
....	5.749	4.071	....	3.758	....	....	5.542
5.097	5.735	4.034	....	3.742	....	....	5.529
....	....	4.050	4.793	3.738	4.607	4.572	5.552

SUMMARY.

Difference of Elevation (T. P. E. 7 — T. P. W. 7).

Date.	**PARTY No. 1.**			**PARTY No. 2.**			**Mean for both parties.**
	Inst. on E. side.	**Inst. on W. side.**	**Mean.**	**Inst. on E. side.**	**Inst. on W. side.**	**Mean.**	
Dec. 16, 1905......	— 0.888	— 0.789	— 0.838	— 0.953	— 0.551	— 0.752	— 0.795
" 18, 1905......	— 0.659	— 0.753	— 0.706	— 0.974	— 0.859	— 0.916	— 0.811
Final mean......							— 0.803

TABLE No. 4.—CIRCUIT CLOSURES—SINGLE LINE OF LEVELS—TARGET METHOD.

Method 1.—One-wire level. Peg method of levelling.

Method 2.—One-wire level. Equal back and fore sights. Two set-ups between turns.

Method 3.—One-wire level. Equal back and fore sights. One set-up between turns.

Circuit closures obtained by Methods 1, 2 and 3.

Circuit.	Length of circuit, in miles.	Error of closure, in feet.	Value of "C" in Eq. $E = C\sqrt{K}$.	Method.	Run by party.
Peekskill Triangle	9	0.145	0.048	1 & 2	1
Hunter's Brook Spur	10	0.018	0.005	2	1
Peekskill—Garrison	11	0.020	0.006	2	1
Garrison—Cold Spring	6	0.061	0.024	2	1
Cold Spring—N. Hamburg	16	0.096	0.024	2	1
N. Hamburg—Camelot	5	0.022	0.010	2 & 3	1
Kingston—Hurley	16	0.060	0.015	3	1
		0.063	0.016	1 & 2	2
Hurley—W. Hurley	9	0.018	0.004	3	2
Highland—Milton	15	0.018	0.005	3	2
Highland—Ulster Park	17	0.094	0.023	3	2
Kingston—Highland	43	0.042	0.007	3	1
N. Paltz—Springtown	9	0.036	0.012	3	1

TABLE No. 5.—CIRCUIT CLOSURES—SINGLE LINE OF LEVELS—THREE-WIRE LEVEL METHOD.

Method 4.

Circuit.	Circuit No.	Miles length of circuit.	Error of Closure, in feet.	Value of "C" in Eq. $E = C\sqrt{K}$.	Run by party.	Remarks.
Peekskill Triangle	I.	9	0.065	0.022	2	
Hunter's Brook Spur	II.	10	0.058	0.018	2	
Peekskill—Garrison	....	11	0.009	0.003	2	
Garrison—Cold Spring	....	6	0.048	0.019	2	
Peekskill—Cold Spring	III.	15	0.084	0.022	2	
Cold Spring—N. Hamburg	....	16	0.021	0.005	2	
N. Hamburg—Camelot	....	5	0.036	0.016	2	
Hurley—Olive Bridge	V.	28	0.036	0.007	2	
Atwood—Olive Bridge	VI.	5	0.012	0.005	2	
Atwood—High Falls	VIII.	13	0.045	0.013	2	
High Falls—N. Paltz	IX.	18	0.151	0.036	2	Rerun by Party No. 1.
N. Paltz—Springtown	XI.	7	0.011	0.004	2	
Butterville—Bonticou	X.	4	0.028	0.014	2	
Kingston—Highland	VII.	48	0.129	0.019	2	
Highland—Cornwall	XII.	50	0.151	0.021	2	
Riverhead—Eastport	A	25.8	+0.150	0.029	1	
Eastport—Yaphank	B	15.8	+0.001	0.000	1	
Calverton—Yaphank	C	30.4	+0.031	0.006	1	
Brook Haven—Lake Grove	D	27.2	+0.096	0.018	1	
Oakdale—Smithtown	E	25.3	—0.012	0.002	1	
Bayshore—Melville	F	27.9	—0.120	0.230	1	
Port Jefferson—Wading River	G	28.6	—0.054	0.010	1	

TABLE No. 6.—CIRCUIT CLOSURES—DOUBLE LINE OF LEVELS. RUN BY TWO PARTIES, EACH PARTY RUNNING A SINGLE LINE. WITH A FEW EXCEPTIONS ALL THE CIRCUITS WERE RUN BY THE *Three-Wire Method.*

Circuit.	Length of circuit in miles.	Error of Closure, in Feet.			Circuit closure per mile for mean.	Value of "C" in Eq. Error = $C\sqrt{K}$.		
		Party No. 1.	Party No. 2.	Mean.		Party No. 1.	Party No. 2.	Mean.
Peekskill Triangle	9	+0.145	−0.065	−0.084	0.0038	0.048	0.022	0.011
Hunter's Brook Spur	10	−0.018	−0.058	−0.019	0.0019	0.006	0.018	0.006
Peekskill—Garrison	11	+0.020	+0.009	+0.014	0.0013	0.006	0.003	0.004
Garrison—Cold Spring	6	+0.061	+0.048	+0.024	0.0040	0.024	0.019	0.010
Peekskill—Cold Spring	15	−0.106	−0.084	−0.070	0.0047	0.028	0.022	0.018
Cold Spring—N. Hamburg.	16	−0.035	−0.021	−0.058	0.0036	0.026	0.005	0.014
N. Hamburg—Camelot	5	+0.022	+0.036	+0.029	0.0058	0.010	0.016	0.013
Hurley—Olive Bridge	28	+0.196	+0.036	+0.102	0.0036	0.037	0.007	0.019
Atwood—Olive Bridge	5	....	−0.012	....	0.0024	....	0.005	....
Atwood—High Falls	13	−0.086	−0.045	−0.063	0.0048	0.024	0.013	0.018
High Falls—New Paltz	18	−0.140	−0.151	−0.052	0.0029	0.033	0.036	0.013
New Paltz—Springtown	7	+0.046	+0.011	+0.017	0.0024	0.017	0.004	0.006
Butterville—Bonticou	4	0.000	+0.028	+0.020	0.0050	0.000	0.014	0.010
Kingston—Highland	43	+0.079	−0.129	−0.047	0.0011	0.012	0.019	0.007
Highland—Cornwall	50	−0.193	−0.151	−0.168	0.0034	0.027	0.021	0.024
Bull Hill Spur	2	+0.020	+0.003	+0.009	0.0045	0.013	0.002	0.006
Breakneck Valley Spur	1.6	....	+0.006	....	0.0038	....	0.005	....
Breakneck Ridge Spur	5	+0.024	+0.011	+0.009	0.0018	0.011	0.005	0.004
Kingston—Hurley	16	−0.060	+0.063	....	......	0.015	0.016	....
Highland—Milton	15	....	−0.018	....	......	....	0.005	....
Highland—Ulster Park	17	....	+0.094	....	......	....	0.023	....

TABLE No. 7.—CIRCUIT CLOSURES—DOUBLE LINE OF LEVELS, THREE-WIRE LEVEL METHOD—RUN BY ONE PARTY.

Circuit.	No. of Circuit.	Error of Closure, in Feet.			Length of circuit, in miles.	Value of C in Eq. $E = C\sqrt{K}$.
		Forward line.	Backward line.	Mean.		
Peekskill—Tarrytown	XIII.	+ 0.182	+ 0.030	+ 0.106	32.6	0.018
Spur—B M 9 to S 32	....	....	....	− 0.001	0.6	0.002
Spur T P S S to S 33	....	....	....	+ 0.009	2.0	0.006
Tarrytown—Dobbs Ferry	XIV.	+ 0.050	+ 0.100	+ 0.075	18.0	0.020
Dobbs Ferry to L. I. City	XV.	+ 0.074	+ 0.079	+ 0.076	25.0	0.014
Hell Gate Circuit	....	....	....	− 0.007	9.0	0.002
Long Iland City—Brooklyn City Hall	XVI.	+ 0.051	+ 0.031	+ 0.041	5.6	0.015
Brooklyn City Hall—Ft. Hamilton	XVII.	− 0.009	+ 0.010	− 0.000	10.0	0.000
Spur Ft. Hamilton—Silver Lake	XVIII.	....	....	+ 0.001	5.5	0.000
L. I. City—Ridge-Prospect Park	XIX.	+ 0.000	+ 0.011	+ 0.006	18.6	0,001
Spur-Ridgewood—Smith's Pond	....	....	....	+ 0.012	12.0	0.004
Spur Smith's Pond—Eastport	....	....	....	− 0.025	51.5	0.003
Spur High Falls—Lackawack	....	....	....	+ 0.109	22.0	0.023

TABLE No. 8.—RESULTS OF RIVER LEVELLING.

Location.	Width of river, in feet.	Discrepancy between two results, in feet.
New Hamburg	2 100	0.007
Camelot	2 100	0.011
1 ½ miles S. of Poughkeepsie	2 600	0.001
2 miles N. of Poughkeepsie	2 600	0.012
Hyde Park	2 600	0.010
Staatsburg	2 600	0.004
Rhinecliff	3 700	0.016
Little Stony Point	2 800	0.008
Harlem River	500	0.004
Bronx Kills	700	0.010
Little Hell Gate	500	0.000
Hell Gate	1 900	0.020
West Channel East River	1 200	0.005
East Channel East River	700	0.010
The Narrows	5 300	0.016

TABLE No. 9.—LIMITS OF ERROR IN VARIOUS ORGANIZATIONS.

Organization.	Limit of Discrepancy, in Feet, between Duplicate Lines.	Reference.
U. S. C. and G. Survey, at present	$0.017\sqrt{L}$.	Report for 1906, Appendix 3.
U. S. C. and G. Survey, 1889-1899	$0.021\sqrt{L}$.	*Trans.*, Am. Soc. C. E., Vol. XXXIX, p. 396.
U. S. C. and G. Survey prior to 1889	$0.030\sqrt{L}$.	Johnson's Surveying (1902), p. 612.
U. S. Lake Survey	$0.041\sqrt{L}$.	Johnson's Surveying (1902), p. 612.
Mississippi River Survey	$0.021\sqrt{L}$.	Johnson's Surveying (1902), p. 612.
U. S. Engineer Corps	$0.017\sqrt{L}$.	Brooklyn Engineers' Club, Vol. XIX, p. 116.
U. S. Geol. Survey. Formerly	$0.030\sqrt{L}$.	*Trans.* Amer. Soc. C. E., Vol. XXXIX, p. 374.
U. S. Geol. Survey. At present.	$0.017\sqrt{L}$.	By Letter.
N. Y. State Barge Canals	$0.020\sqrt{L}$.	Report of Wm. B. Landreth, 1902.

TABLE No. 10.—TARGET LEVELLING IN RESERVOIR DEPARTMENT.

Circuits 1 to 10 incl. were single line.

Circuits 11 to 14 incl. were double lines.

Circuit.	No. of circuit.	Length of circuit, in miles.	Error of closure, in feet.	Value of C in Eq. $E = C\sqrt{K}$.
Ashokan Reservoir Site	1	2.3	+ 0.003	0.002
" " "	2	1.6	− 0.021	0.017
" " "	3	5.4	+ 0.040	0.017
" " "	4	9.5	− 0.098	0.032
" " "	5	3.1	− 0.039	0.022
" " "	6	11.4	− 0.081	0.024
" " "	7	3.7	− 0.019	0.010
" " "	8	2.2	− 0.033	0.022
" " "	9	1.6	− 0.038	0.032
" " "	10	5.4	+ 0.010	0.004
Shokan to Phoenicia	11	18.2	+ 0.085	0.020
Phoenicia to Shandakan	12	7.9	+ 0.004	0.002
Shandakan to West Kill	13	16.6	− 0.074	0.018
West Kill to Prattsville	14	21.0	− 0.167	0.036

DISCUSSION.

Mr. Robert Ridgway.—This important paper was given much careful study on the part of the author and I think it should bring out a good discussion to-night.

It is interesting to note that when the Board of Water Supply first began its work, the subject of datum planes was taken up by its engineers and given a great deal of consideration. It was at once realized by them that the plane of the United States Coast and Geodetic Survey was the only one to be used, and it was adopted without hesitation or question. It is to be regretted that such a datum was not available for those who establisht the early bench marks of the City, so that all levels here could now be referred to one plane, instead of to a dozen or more.

Mr. White, who was Chairman of the "Special Committee on Datum Planes" in 1905, ought to have something interesting to say on this subject.

Mr. L. White.—It is just three years since the original Datum Planes Committee reported on the relation between the various datums in use by the different departments in New York City. This report, though rather brief, was the outcome of extensiv investigation and the condensing of a great deal of information obtained from various departments. Its main purpose, to present in a simple form a card or table by the aid of which one could obtain at a glance the relation between the datums, was realized in a satisfactory manner. Altho this card has been widely distributed and has been in use three years, it has not, to my knowledge, been criticized. The information therein shown is therefore assumed to be about correct. Nevertheless, in the three years elapsed there have been some changes in the departments, and one or more of the departments have overhauled their systems of levels. In addition, the Board of Water Supply, with a jurisdiction extending from the Mohawk River to Montauk Point, has been organized, and run hundreds of miles of levels, establishing many level lines thruout New York City. The party which did the most of this work has had the advantage of all the information covered by the old Datum Planes Committee, and in a large measure expanded their work. It is a pleasure to state that in nearly all cases the publisht card was very closely checkt.

The Board of Water Supply was the first department to adopt as their datum the mean high water at Sandy Hook, establisht by the Coast and Geodetic Survey. It may be said that their adoption of this datum was largely influenced by the work of this society. There were strong temptations for the Reservoir Department to use the U. S. Geological Survey benches, altho this datum was supposed to be identical with that of the Coast and Geodetic Survey. The

Northern Aqueduct Department used the Coast and Geodetic Survey datum as their work was parallel to the Hudson River. It was more natural, however, for the Southern Aquedect Department to use the Croton aqueduct datum, as a good deal of their work was parallel to the New Croton Aqueduct. In the same manner the Long Iland Department was tempted to use the excellent system of benches establisht by the Brooklyn Department of Water Supply, Gas and Electricity. Nevertheless, the Coast and Geodetic Survey datum is in use by all the departments of the Board of Water Supply. For this great credit is due to the work of Mr. Goodman.

At the time of the report of the old committee there were few reliable Coast and Geodetic Survey benches left in New York City, and those that were left were mostly in Brooklyn, none existing in Manhattan or The Bronx. By the work of Mr. Goodman's party, a series of levels has been run thru The Bronx, Manhattan, Brooklyn and Queens, extending even to Richmond. As all these benches are tied in to the Coast and Geodetic Survey benches, and have been run with an equal degree of accuracy to the Coast and Geodetic Survey methods, there are now plenty of benches referred to the Coast and Geodetic Survey datum in New York City. This society adopted a resolution two years ago recommending a series of bench marks to be establisht by the Coast and Geodetic Survey thruout Greater New York. This recommendation has not been carried out, but luckily, however, the same work has been done by the Board of Water Supply, in line with the wishes of the society.

The time now seems ripe for the forming of a new committee to complete the work of the original Datum Planes Committee and prepare a new card with the information now at hand. As far as I know there is an addition that might well be made on the revision of the card. The Highway Department of Brooklyn straightened out its benches and adopted an elevation for the Navy Yard bench mark so that they might have a new and consistent datum.

A new committee should also publish, in convenient form, a list of the bench marks with their elevations establisht by the Board of Water Supply, together with such other bench marks of the Coast and Geodetic Survey and other departments as is deemed advisable. All these bench marks should refer to the elevations in terms of the Coast and Geodetic Survey datum. With a new card and a new and accurate list of benches, it would be easy for any department so desiring it, to officially adopt the Coast and Geodetic Survey datum, or to adopt and establish the difference between their old datum and that of the Coast and Geodetic Survey. It seems to be the opinion of most of the Chief Engineers that the Coast and Geodetic Survey datum could be legally adopted by any department provided that an establisht difference with their old datum is at the same time officially fixt.

In regard to the methods of levelling, it seems to the writer that the method in use by most of the departments is an expensiv and inaccurate one. This is due to the use of the New York rod with target and "Y" level. No two New York rods are exactly alike, and all have errors at the joint. Very careful levelling has been done by different parties, and as a single rod is used in most cases very good checks are obtained on the starting benches. This, however, is no guarantee that the intermediate benches are right, due to the fact that no one rod is exactly right. As level lines have been run in different departments with different rods, and no attempt has been made to correct for their length, great confusion in the benches has resulted. Discrepancies in benches is a source of great trouble and expense in the running and the re-running of benches. With the knowledge we have at the present time, this is altogether inexcusable.

A dumpy level with two extra horizontal wires and the use of a single piece, self-reading rod, the length of which is carefully taken with the aid of a steel tape at intervals, is a sufficient equipment to run very precise levels. In fact, Mr. Goodman has, with this equipment, run levels as quickly and accurately as those of the Coast and Geodetic Survey.. The Board of Water Supply started originally with the usual system of "Y" level and target, and less than two miles could be done with this equipment with a very good party. This was not long in use before a change was made to the 3-wire system and self-reading rods, and four times the speed was obtained with much less liability of error. Levelling is an exception to the usual rule; the greater the speed the greater the accuracy with a corresponding reduction in cost. It is therefore all the more inexcusable to use the old cumbersome target methods. Mr. Goodman has expanded the investigations of the original committee so as to cover more fully the question of changes in mean sea level.

The determination of 1876-81 at Sandy Hook is confirmed by the long and accurate series at Fort Hamilton, extending from 1892 to 1906. It is found that the mean of these two series separated by twenty years, is exactly the same, that is, the tidal bench mark independently establisht at Fort Hamilton from observations on the tide checks exactly when tied in with the original Coast and Geodetic Survey levels on Fourth Avenue.

MR. RIDGWAY.—Perhaps Mr. Tuttle can give us some light on the recommendation of Mr. Goodman.

MR. ARTHUR S. TUTTLE.—In 1905 a report was presented to this Society by a Committee, of which Mr. Lazarus White was Chairman, appointed to investigate the relationship of the datum planes used by the various boros and departments in this City. The results of this investigation have proven both invaluable and timely, and I believe that the data presented are to-day accepted by all without question. The interest which was then aroused led to the appointment of a Committee charged with the responsibility of bringing about a co-operation between the City and the U. S. Coast and Geodetic Survey in running a series of precise levels covering all of the boros. As Chairman of that Committee I made "progress" reports from time to time, until the matter was finally lost sight of as one of live interest to the Society. It might be pertinent to again state in this connection that the Chief Engineer of the Board of Estimate and Apportionment was very much interested in the proposition, and without delay took up the matter with the proper officials of the U. S. Government. The negotiations indicated that it would be advisable to defer commencing the work until the triangulation then in progress had been finisht, and that when it was begun the Coast and Geodetic Survey officials would lend all proper assistance in their power. The triangulation is now practically complete, making this a fitting time to revive the proposition. The work described to us by Mr. Goodman seems to have been carefully done, altho his method appears to be radically different from those used by the U. S. Government. I believe that a further investigation of the scope and methods to be recommended for the work is very desirable, and that this could be properly left to a new Committee as suggested. The plans prepared by the various departments, as we all know, refer to imaginary datum planes, each of which has undoutedly been adopted for convenience, but the exact position of which is, notwithstanding the work heretofore done, a subject of dispute. It would doutless result in serious confusion if each should depart from previous practis and adopt a new plane which might be agreed upon in common, but I can see no reason, legal or otherwise, which would prevent the inclusion of a note on all plans explaining the relationship between the datum used and the one it is desired to accept. This course would probably be followed without friction and would doutless ultimately result in discarding the old datum, altho the process of supplanting it would be a gradual one.

MR. RIDGWAY.—I think Mr. Culver could tell us something about the earlier system of levels in the city, if he will be good enough to speak.

MR. A. G. CULVER.—The benches now in use by the departments of the City of New York were originally started from the old bench mark at Twenty-sixth Street, in the Bellevue Hospital, a good many years ago. Starting from this bench mark, a line of levels was run thru Twenty-sixth Street and also up Third Avenue to the Harlem Bridge. A line was also run up Eighth Avenue and cross lines every five blocks apart, leaving bench marks on all of the street corners. At that time the benches were in a state of chaos, as they are now, and every surveyor and every engineer had his own bench marks, but the Commissioner of Public Works thought it would be a good idea to have one line of benches establisht, and consequently the work was done at that time, and those benches are now used by most all of the departments. They were run with a great degree of accuracy, with the instruments available at that time, which was in 1881 or 1882. These benches were iron bolts set in the water tables of bildings, houses and permanent structures wherever they could be found, and they are still in existence, and a great many of them are still used as the datum for public works in nearly all of the different departments.

In running those benches, the New York rod was used and an average was taken of all the readings. I think the difference in running up Third Avenue, over to Eighth Avenue and back to East Twenty-sixth Street, was between .03 and .04 ft. in a distance of about 12 or 14 miles.

Mr. Edward H. Holden.—I would like to ask Mr. Culver if a bench mark was left on Third Avenue at the old Harlem Bridge.

Mr. Culver.—There was one left in the foundation or wall on the Harlem side of the old Third Avenue Bridge.

Mr. Holden.—The origin of benches in the Boro of The Bronx was the mark, 10 ft. above mean high water, on the Bronx side of the old Third Avenue Bridge over the Harlem River. This bench agrees with the Manhattan datum. Several bench runs have been made from this bench to that at the High Bridge tower.

Mr. Ridgway.—Has Mr. Taber anything to say on this subject.

Mr. George A. Taber.—The City of New York is certainly in need of a uniform system of levels and one that can, eventually, at least, be used in common by all departments. While it is well known that there are differences between the datums used by the different city departments, yet there is at least one department which used two datums, and this, to one unacquainted with the conditions, must prove very confusing.

The plans of the Aqueduct Commissioners, for all construction work on the Croton watershed, give elevations referred to the "Croton Aqueduct Base," which is mean tide at Ossining, and was establisht in the early "Forties" when the Old Croton Aqueduct was bilt. If one looks over the plans of say the New Croton Dam, he will find that the crest of the spillway is at Elevation 200. If he should visit the dam he would see a bronze tablet on the gate house that states that the crest of the spillway is at Elevation 196.4. This apparent discrepancy is due to the fact that the figures on the plans refer to the "Croton Aqueduct Base" while those on the bronze tablet to what is known as "City Base," which is mean high water at East Twenty-sixth Street, New York City. Moreover, the plans of the Jerome Park Reservoir in the northern part of the City, give all elevations referred to "City Base," while those of the New

Croton Aqueduct, which passes directly underneath the reservoir and connects therewith, refer to "Croton Aqueduct Base."

To one acquainted with these conditions no great trouble need occur by the use of these two datum planes, but to the uninitiated, it must cause considerable confusion and might possibly lead to serious error.

The speaker is of the opinion that the universal adoption of one common datum plane would be of the greatest benefit to all departments of the City, but that such adoption should be brought about gradually, and the first step should be the establishing of universal bench marks available to all departments, and in placing the information as to their location and elevation before all who may be interested in their use.

Mr. Henry W. Vogel.—The main object of the City of New York would seem to be to adopt a datum plane which would be used universally by all of the departments; but how to bring about that result seems to be somewhat doutful. It has been said that the Committee on Datum Planes reported some three years ago and that nothing definit has been accomplisht. If we once had a set of standard benches located in all of the different boros, it would be a simple matter for each department to check the benches, in its own boro, and adopt a datum plane on all maps subsequently filed, stating that the datum plane used on the maps is the mean sea level, and that all maps used or filed in any office of record, or in their own department prior to a fixt date should have a constant added or subtracted. It would be very similar to the laws past at Albany. When a new law is enacted changing laws previously past, it is impossible to take from the laws recorded in every lawyer's library all the former laws that are amended or superseded, but in new laws the amendments are simply noted. In the same way on maps that are filed after a fixt date, a universal datum plane could be used by all departments, with a reference to the fact that the datum plane used on these maps can be applied to former maps by adding or subtracting a fixt amount.

Mr. Ridgway.—I would like to hear from the Dock Department, if any member is present. Is Mr. Wimmer present?

Mr. Robert A. Wimmer.—As far as the Dock Department is concerned, they have about eighteen or nineteen different tide gages situated thruout the City, extending from Pelham Bridge to Jamaica Bay. Mean low water at the Battery is usually adopted because most of the work is in reference to low water. All piles are cut off below mean low water, and that datum is used on account of the shipping. They want to know just what range of tide there is, in reference to landing boats at the different piers.

Altho the datum at the Battery is used for the elevations of the different bench marks thruout the City, at the same time from these different tide-gage records, the elevation of the tides at each particular part of the City can be told. The tide gage at the Battery has been in operation since about 1886, up to the present date. Only one change has been made there, and that was in 1898, when a change of 0.24 was made, after a twelve-years average had been obtained. Up to the present day, a twenty-two-years average gives a difference of only 0.02 ft. from the datum establisht in 1898.

We have benches thruout the City. Those benches were run a number of years ago, and there is no dout but that some of them ought to be re-run along the water-front, on account of filling in, etc., which naturally has caused the soil to either rise or sink, according to local conditions.

It certainly would be appreciated by the Dock Department if there were permanent bench marks establisht thruout the City.

MR. RIDGWAY.—Can we hear from Mr. George W. Tuttle?

MR. GEORGE W. TUTTLE.—I think it would be well worth while for the different departments to agree on a common datum, instead of making use of so many different ones. Of course there would be some little trouble involved in making the change. I believe, however, that if the new datum should be universally adopted, the advantages would be so great that the labor involved in making the change would be relativly insignificant, particularly if the adoption of the new datum was accompanied by the placing of permanent and accurate bench marks. I differ in regard to the permanency of mean sea level from some of the previous speakers, and while this level is undoutedly the most constant of any of the tidal planes, as well as that which can be determined most easily and accurately, still it is subject to considerable meteorological changes from month to month and year to year. I believe that the tidal data of New York Harbor between the years 1875 and 1902 show an apparent increase in elevation of mean sea level in excess of 0.3 ft. There is no proof, however, that this rate of change will continue indefinitly; in all probability it will not.

MR. ALFRED D. FLINN.—In compiling the results of his work in the office of the Board of Water Supply, Mr. Goodman collected a great deal of information from other City offices, and, when his report was completed, copies of it were filed with many, if not all, of the offices; certainly all of those which furnisht information from their files to the Board of Water Supply. This information, I understand, will largely be made available in Mr. Goodman's paper, to be publisht in the *Procedings* of this Society.

I also gather, from what Mr. Goodman has said and what others have said here to-night, that the work of establishing a system of bench marks on which a uniform datum could be based has largely been accomplisht by the circuits run by Mr. Goodman, partly for the Board of Water Supply and partly for the former Rapid Transit Commission. If I am rightly informed, a few circuits in The Bronx and the Boro of Queens, and possibly in the lower part of Manhattan would sufficiently complete this system to make it acceptable, at least, if the other departments would check their own references as has been suggested here to-night.

There is another point in Mr. Goodman's excellent paper perhaps worthy of a little additional emphasis, and that is the use of the dumpy level for such extensiv and very important levelling. I believe this is somewhat of an innovation in accurate levelling work and the economy and speed secured by it certainly deserve to be brought to the attention of engineers having this kind of work to do.

Mr. Ridgway.—We have not heard from the Boro of Queens. There must be some one present from that boro who can tell us about their work. Perhaps Mr. Crowell can say something.

Mr. Robert R. Crowell.—In 1869 the Legislature past an act dividing the old Town of Newtown into two parts, one of them being called Long Iland City. One of the provisions of the act was that the Commissioners who were appointed for the improvement of Long Iland City should create a datum plane from which to do their work. These Commissioners establisht a bench mark on the old land house on Blackwell's Iland. From that all the benches in Long Iland City have been run.

In regard to the sea level plane. While that may be all right for the Department of Water Supply, Gas and Electricity, or the Board of Water Supply, it does not apply so well to the Street Departments of the City.

We have a great many maps on file which have establisht streets according to the datums which have been used, and if you attempt to change all those maps and legalize them you will find it is a great undertaking.

Mr. Ridgway.—Mr. William G. Ford can, I think, throw some light on the question.

Mr. William G. Ford.—The work I have been mainly connected with, has been the problem of trying to develop Jamaica Bay, that low marsh district, into a supplemental harbor for New York. In the levels used there great respect was had for what the Dock Department has done. In fact, everything we found there that the Dock Department had done we accepted with absolute confidence. There are a series of levels being taken there now under direction of the U. S. Army Engineer, with whom our Commission is in conference, and I think that by the cold weather we will have a series of simultaneous observations that will throw some additional light upon the attitude of the tides.

There is one problem that came up which was interesting. There has been an effort by some of the people in Queens County to have a canal put thru from Jamaica Bay into the Great South Bay, and it was referred, by an Act of Congress, to the Army Engineers for report. The principal argument in its favor was that it would give cheap transportation.

There has been a good deal of argument recently upon the proposition that when Jamaica Bay is opened to commerce it will need a good deal of flushing out, and that if a large flow of water from Great South Bay could be brought in, at what they call the "Head of the Bay," it would increase the currents over the bar, help to keep the channel open, and reduce the cost of maintenance.

The point in favor of this current from Great South Bay has been strongly advocated outside of the Commission, and on account of the persistence with which it was brought up I plotted the tidal conditions in the two bays. This demonstrated a very serious objection to the plan, which was that the current would run the other way.

MR. GOODMAN.—Before starting the levels in New York City, the speaker obtained all available information from the former Committee on Datum Planes and afterwards wrote a letter to each department, showing on the map where the level line was to be run and asking for the latest official bench marks, so that in starting the level lines, the party, which had already run about 600 miles of levels, would have complete data at their disposal and be sure to make no mistakes in connecting the departments.

As regards the accuracy of the work and desirability of having the Coast and Geodetic Survey re-run new levels, the speaker desires to say that the very close checks shown to-night on the Board of Water Supply circuits, and also the close checks, well within the limit of accuracy, with the bench marks of the U. S. Coast and Geodetic Survey, show that the Board of Water Supply level line for any purpose is as good as that of the U. S. Coast and Geodetic Survey.

Further, I desire to state that the use of a precise level does not necessarily give a precise level line, that the method of levelling is the essential point, and that simply to use an organization bench mark because the level looks good on the picture is no guarantee of its accuracy. The U. S. Coast and Geodetic Survey benches are run along the latest scientific lines. Those lines were thoroly understood by the speaker in running the levels of New York City, and the method of running the levels is very similar. On account of the very close checks on the City departments' work shown in New York City, it seems to me that, taking the Public Service Commission lines, for instance, an official list of bench marks based on their levels could be establisht. The only objection to that would be in not having all the levels thoroly recorded as to their origin, in case they come into question at some future time.

MR. CROWELL.—I would like to ask Mr. Goodman where this thirteen miles was run in eight hours. He laid a great deal of stress on that fact, and I would like to know where it was.

MR. GOODMAN.—It was run between High Falls and Napanoch, in Ulster County, along the railroad, and a greater speed would have been obtained if we had had velocipede cars. The walking delayed us.

MR. L. WHITE.—I thoroly agree with Mr. Goodman; it is unnecessary to have the Coast and Geodetic Survey run any more benches in New York City. This work has been well done by the Board of Water Supply and perhaps more thoroly than they could do it, as it was run by local men, who understood conditions. There are about thirty permanent benches in existence now, in parks and on bildings, and they extend to all five boros. There is no question about their accuracy and there ought to be no hesitation in using them. Altho I proposed the original resolution to have the Board of Estimate co-operate with the Coast and Geodetic Survey, to have these benches run, I now believe that to be unnecessary. This work ought not to be stopt, and I therefore propose that the Chairman appoint a Committee of, say, seven, at least one from each boro, to revise the card gotten out by the original Datum Plane Committee, if they think there is any change to be made on that card, and also to publish a list of bench marks, including those of the Board of Water Supply, other departments, and the Coast and Geodetic Survey, this list of bench marks and description to be publisht by the Society and distributed the same as were the original cards. There can be no obligation in this. The original card was not forced on anybody, and still, I understand, it is used by almost all departments. It is the same with this list of bench marks.

If this committee cares to do so, they can make a recommendation about the adoption of a common datum plane for the use of all departments. I cannot see how it changes any of the previous maps. All that is necessary is to put a note on the new maps that the datum plane has such and such a relation to the old datum. As for changing any street grade, it doesn't; it simply moves the origin of the levels, that is all. If a person is so many feet above high water it don't make any difference if you call it a thousand or one; it is all the same. It is necessary to have tide-gage readings anyway, with any department thruout the City, no matter what you call the datum, but the Dock Department at present have establisht these variations in different parts of the City, and they can be used by any department to find out the range of tide and how much to allow for high or low water. So, therefore, mean sea level would accomplish this same purpose. It would be a real level instead of an imaginary one for high and low water. I understand you can get a difference of several feet, in traveling a few thousand feet along the water front of the City, in high and low water in New York City, so it really means nothing.

Mr. Herman K. Endemann.—I would like to suggest that if a list of bench marks be compiled, that the elevation be given according to two datums; in one colum put the mean sea-level datum elevation advocated by Mr. White, and in the other put the elevation according to the datum of the particular department which originally establisht the bench mark. It seems a very simple matter when talking about it here, to inaugurate a change of the kind advocated by a good many of the speakers to-night, but in Queens Boro we had an experience in making a change of a similar nature, of about 0.48 ft. The amount of work and confusion which resulted therefrom was more than anyone could imagine, unless they had previously attempted something of the same kind.

A Member.—Does not Mr. White's motion cover that? The motion says nothing about compelling any department to adopt a new datum, simply to publish a list of bench marks. The idea would be to have them there convenient for the use of the departments of the different boros. You would have a card, as we have it already, establishing the difference between the Coast and Geodetic Survey datum and the datum of any other department; then you would have a list of bench marks and with those two in view you can change from one system to the other at will.

Mr. Crowell.—I would like to ask Mr. Goodman if, in running over the benches given him by the different departments thruout the City, he found any large errors or discrepancies in the relativ elevations.

Mr. Goodman.—As a general thing, the checks were very good, and in very few cases was there a variation of more than a tenth, using the official bench marks, and in every case where there was a regular level survey, as in the Brooklyn Highways, The Bronx, the Public Service Commission, the Department of Bridges, the system of levels checkt almost exactly. The writer tried to look up and find out how the levels were run. In every case where a system of levels were run he found he checkt very closely, much within any practical limit.

Mr. Ridgway.—That is, the levels of several departments were consistent in themselves?

Mr. Goodman.—Yes.

Mr. Charles A. Sullivan.—I would like to ask what was the length of the greatest circuit run in the levels?

MR. GOODMAN.—There was a line run from Ridgewood to the end of Long Iland, a distance of about 53½ miles. The return line, run directly back over the same route, never varied at any point more than 0.06 ft. It closed by about 0.02 ft.

Using our lines and the Government lines the checks were very satisfactory. In a great many cases the Board of Water Supply ran their own circuits, and the checks of the Board of Water Supply circuits were usually much better than the closers on the government primary level line.

MR. SULLIVAN.—It is expected that relativ elevations of bench marks in one system will check within the limit of error when used in another system. Were your levels carried from an initial bench mark thruout the entire circuit and returned to the starting point independently, or did you change the elevation to agree with the recorded elevation at each succeeding bench mark of the original system? Also what method did you use in eliminating the wedge of level error in adjusting the elevations of intermediate bench marks? I have run a circuit of twenty-two miles myself and in that circuit the Government lines were crost twice. The variance with the Government in itself, after about a twelve-mile run was .04 ft., but carrying the circuit around and re-running it in the opposit direction, the two lines never varied more than ¼ in. Those were the levels taken in the Boro of Queens.

In running levels rapidly on a sunny day, and then re-running the same line on a day that is cloudy, or when there is moisture in the air, which day gave you the best results and how did they agree with one another?

I have found that during the season of intense heat, even with 260-ft. sights, the greatest difficulty in precise observing was caused by the heat vibrations. I also found in such weather conditions much better final results were obtained by suspending work from 11 A. M. to 2 P. M.

MR. GOODMAN.—In sunny weather the greatest effect on accuracy was the effect of the sun on the bubble. It was found if you ran in one direction and then returned over the same line in a sunny condition, you would get a wide divergence between the lines, and in general this meant that on sunny days you had to have an umbrella, and when you had an umbrella you could largely eliminate the error and come within the allowable divergence of level lines.

The results obtained on cloudy days emphasized the fact that uniformity of air conditions is highly desirable, as usually the fore and back runs on cloudy days gave almost identical figures. Moisture steadied air conditions, helping the accuracy of the work.

The following table shows the continuous divergence between the duplicate level lines run, as well as how the continuous results of the

Board of Water Supply levels checkt the work of the U. S. Coast and Geodetic Survey.

Locality.	Distance along Board of Water Supply lines.	Divergence of Board of Water Supply level lines,	Closure on U. S. Coast and Geodetic Survey Bench Marks.
	Miles.	Feet.	Feet.
Kingston to Highland........	48	0.208	— 0.047
" " Cornwall.....................	98	0.166	— 0.215
" " Peekskill....................	108	0.144	— 0.145
" " Tarrytown..................	140	0.092	— 0.069
" " Dobbs Ferry.................	158	0.142	+ 0.098
" " L. I. City....................	181	0.147	+ 0.112
" " Brooklyn City Hall.........	187	0.127	+ 0.158
" " Ft. Hamilton................	197	0.126	+ 0.158
" " Ridgewood..................	188	0.179	....
" " Rockville Centre...........	200	0.189	....
" " Eastport.....................	252	0.164	....

THE MUNICIPAL ENGINEERS
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MUNICIPAL WATER-WORKS IN THE FAR EAST.

BY MR. GEORGE A. JOHNSON,*

WITH DISCUSSION BY

ROBERT RIDGWAY, ERNEST L. MANDEL, DANIEL D. JACKSON, NOAH
CUMMINGS, MAX L. BLUM, GEORGE A. TABER,
AND THE AUTHOR.

Only in very recent years has attention been directed to the quite remarkable progress which far eastern countries are making in water-works matters. Such information travels but slowly from that part of the world and as a matter of fact very few authentic articles on this subject have appeared in the current engineering press during the past ten or more years.

The works existing to-day disclose no very unusual features as to construction and operation, the plants being for the most part patterned after European and American ideas, and methods of operation follow along lines well understood in this country. Construction costs vary according to the standards of the individual countries, but do not differ radically from the average American practis. Labor is cheaper in all far eastern countries but necessarily less efficient. Labor-saving devices are more or less a rarity, the coolie largely taking the place of the horse, the steam shovel and the travelling crane. Except perhaps in maintenance charges, a dollar does not go much farther in Japan, China or India than here, but the character of the work done does not suffer greatly by comparison.

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* Of firm of Hering & Fuller, Consulting Engineers, 170 Broadway, New York City.

The wage scale in Japan is a source of considerable surprize to the Occidental. A chief engineer in charge of millions of dollars' worth of work frequently receives not more than $125 per month while skilled and common labor wages seem even lower. Daily wages in United States gold, which are practically standard for labor of the latter class, are as follows, nine hours being the working day: Foreman, 30 cents; brick masons, 35 cents; stone masons, 47.5 cents; asphalt layers, 40 cents; mechanics, 32.5 cents; carpenters, 35 cents; apprentices, 20 cents; laborers (male) 17.5 cents; laborers (female), 10 cents. For a thirty-day month these figures become $9, $10.50, $14.25, $12, $9.75, $10.50, $6, $5.25 and $3. It may be of interest to some to learn that the Japanese police officer receives $15 per month, out of which he is expected to clothe and feed himself. These officers are a model of neatness and curtesy.

JAPANESE WATER-WORKS.

It may surprize the majority of those interested in this branch of municipal work to learn that in Japan to-day there are public water supplies in 13 cities and towns designed to serve a total population of more than 4 500 000 people. In 10 of these 13 cities, embracing a total population of 4 000 000 people, the water is filtered thru slow sand filters.

The necessity for the filtration of Japanese water supplies is greatly accentuated by the universal use of human excreta as fertilizer. Not a little has been said about this method of sewage disposal which appeals to every casual observer as an excedingly unsanitary procedure. The writer has personally inspected many acres of Japanese farm lands and can say that there is no dout about the excreta as applied getting onto the growing vegetables, many of which are afterwards consumed uncookt. While this excreta is stored in tanks for a considerable period before use, and while this practis must result in the destruction of a large proportion of pathogenic germs which the excreta contains, it is obvious that a not inconsiderable amount of dangerous polluting matter is washt into the streams at time of heavy rains, and where the waters of such streams are used for domestic consumption, the necessity for thoro purification is clearly obvious.

A feature in existing Japanese water-works systems is that about one-third of all service lines are metered, and that there is a fire hydrant to about every 50 houses. It is necessary to point out that even tho fire hydrants are comparativly plentiful, on account of the extremely inflammable nature of the Japanese bilding, prodigious areas are occasionally burned over as shown by the recent experience at Hakodate, where practically the whole population of 60 000 people was rendered homeless by fire. There were upwards of 400 fire hydrants in Hakodate and storage capacity for 3½ million gal. of water.

Water consumption in Japan is uniformly low, averaging about 25 gal. per capita daily. This does not mean that the Japanese are not a cleanly race, for on the contrary there is no nationality on earth as a unit so conscientious in the matter of his daily bath as the Japanese. There are also many public fountains, and the streets are always well watered, often it must be admitted, with water from the gutters in which so often flow the cities' wastes, but which wastes contain only a very small proportion of the human excreta of the population. As in all things the Japanese are careful and saving in the matter of water consumption.

The total cost in 1906 of all existing water-works in Japan, having a total capacity of about 100 million gal. daily for 13 cities and towns, was $11 500 000, or about $2.68 per capita.

THE TOKYO WATER-WORKS.

The first public water supply in Japan was inaugurated in 1600 at Tokyo by Iyeyasu, the founder of the Tokugawa dynasty of Shoguns, and who, with his successors, virtually ruled Japan until the restoration in the middle of the last century some 260 years later, when the present Emperor in name became Emperor in fact.

Iyeyasu's first water supply was derived from small rivers and ponds, and in addition to being far from pure was deficient in quantity. Some 65 years after the inauguration of the first works, and some 240 years ago, the source of supply was changed to the Tama river and a more extensiv system constructed, parts of which are in actual use to-day. Distribution was effected by canals, of which there were some 25 miles, by closed and open condits, of which there were 2.5 miles, and by some 55 miles of iron and wooden pipe.

In 1892 the present improved and up-to-date system was put under construction, and in 1898 it was completed and put into service. The original design called for suitable settling basins, filters, reservoirs and pumping equipment to serve a population of 1 500 000 people. The original works have been so extended that they now serve a population of about 2 000 000 people.

The Tokyo water-works are located at Yodobashi on the western outskirts, and about 4 miles from the heart of the city. The water is conveyed to this point from the Tama River thru the old canal, about 25 miles long, and a new canal about 2.5 miles long, a short section of the latter near the Yodobashi works being lined with concrete. The fall from the intake to the works is roughly 1 in 500.

The raw water, except during the rainy season when it becomes very muddy, is comparativly clear, colorless and soft. During the rainy seasons the periods of muddiest water are usually of about two weeks' duration. The water-shed, some 200 sq. miles in extent, is largely used for agricultural purposes, and the washings from these fields are responsible for the very muddy conditions of the raw water during such seasons.

On reaching the works at Yodobashi the water is led into settling basins thru an open canal, lined with concrete, where a solution of potash-alum, running about 10 per cent. available alumina, is applied when the turbidity of the raw water is high. Use is made of this coagulant during about 30 days in the average year, when on an average about 1.2 gr. per gal. are applied. The chemical is made in Japan and costs $30 per ton delivered at the works.

The settling basins are three in number, each 720 by 360 by 19.5 ft. average depth, have a total effectiv capacity of about 67 million gal., and may be workt continuously or intermittently. With a water consumption of 45 million gal. daily, the period of sedimentation when the basins are operated continuously is equal to about 36 hr. The velocity of flow at such times is about 0.067 in. per sec.

From the settling basins the clarified water flows thru inlet regulators to 18 slow sand filters. The filter tanks are each 258 by 168 by 9 ft. deep, corresponding to a total filtering area of about 18 acres. The main effluent collecting channels are of concrete, and lateral collectors are formed by two layers of brick set on the side:

PLATE 70.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
JOHNSON ON MUNICIPAL WATER-WORKS OF THE FAR EAST.

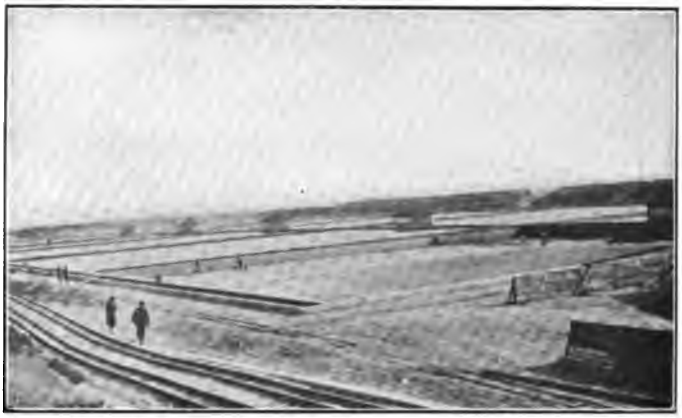

Fig. 1.—General View of Filters, Osaka Water-Works, Japan.

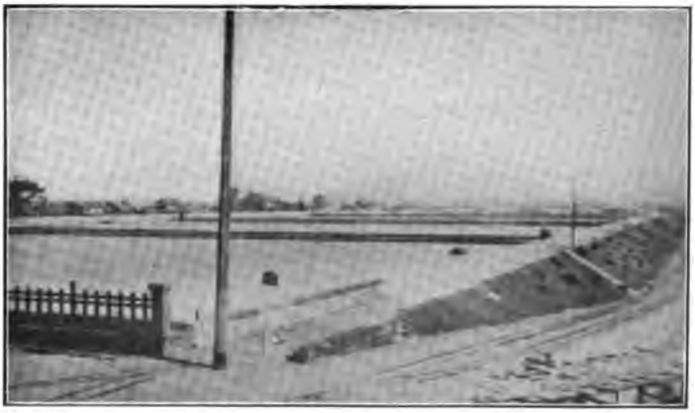

Fig 2.—Settling Reservoirs, Osaka Water-Works, Japan.

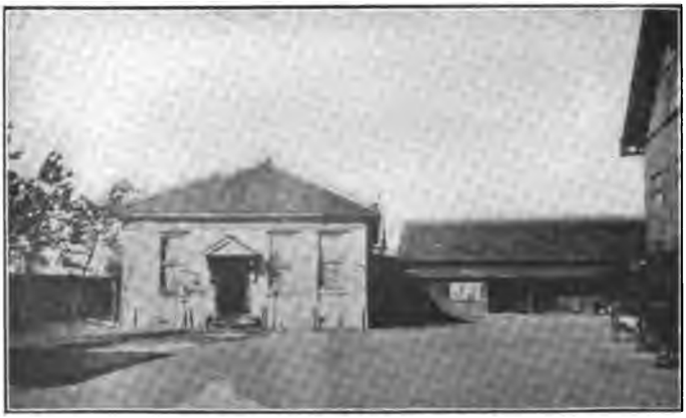

Fig. 3.—Offices and Drafting Rooms, Osaka Water-Works, Japan.
Pumping Station in Foreground on Extreme Right.

Over these are placed 24 in. of graded underdraining material supporting 30 in. of medium fine sand.

Ordinarily a water depth of about 33 in. is carried over the sand surface, and the rate of filtration is ordinarily about 3 million gal. per acre daily. The total gross capacity of the filters is therefore about 53 million gal. daily. As a rule the filters are scraped 7 times in an average year, the dirty sand being conveyed by coolies to cement-lined troughs into which it is dumpt, water applied and the sand agitated with rakes until clean.

The filtered-water reservoirs are three in number, are all covered, and are located respectivly at Yodobashi, Hongo and Shiba. About two-thirds of the population of the city are supplied by gravity from the two latter reservoirs. The high-level district, embracing the remaining one-third of the cities' population, is supplied by direct pumpage from the Yodobashi station.

The average daily water consumption in Tokyo amounts to about 17 gal. per capita, varying from a maximum of 23 to a minimum of 12 gal. The charge for water varies according to the use to which it is put and ranges from 4 cents to 10 cents per 1 000 gal. and is clear, soft, practically colorless and in all ways high-grade.

The pumping station at Yodobashi contains four 300-h.p. pumping units of the Worthington type, each having a capacity of 7½ million gal. per 24 hr. under a total working head of 80 to 100 ft. There are twelve Lancashire boilers and two sets of Green economizers.

There are over 400 miles of mains in the distributing system, ranging from 4 to 44 in. in diameter. There are in service over 250 district meters and 20 000 smaller meters. The total cost of the works at the close of 1906 was $4 130 000.

These works are being extended and improved constantly, and present an admirable appearance. Dr. Y. Nakajima is Chief Engineer of Tokyo, and among his many duties falls the charge of the water-works.

THE YOKOHAMA WATER-WORKS.

The city of Yokohama, located about 17 miles south of Tokyo, is the main seaport of Japan and has a total population of about

330 000 people, of which some 10 000 are of foren birth. The first water-works were put under construction some 24 years ago, when pipe lines were laid from the Sagami River to Nogiyama, the site of the water-works plant. Since that time the intake has been moved to the Doshi River, near the foot of Mt. Fuji, and from there to Nogiyama, a distance of some 30 miles, the water flows by gravity.

The raw waters of the Doshi are not unlike those of the Tama at Tokyo, ordinarily being comparativly clear, colorless, soft and moderately polluted but turning to very muddy following heavy rains. The writer has no data to prove his assumption but owing to the fact that the water-shed of the Doshi River is used extensivly for agricultural purposes and that human excrement constitutes the chief fertilizer, pollution of the raw water must increase enormously at time of heavy rains. The ordinary alkalinity of the water is about 27 parts per million.

The water-works are located on the western outskirts of the city about 160 ft. above sea level and were originally designed to serve a population of 70 000 people but have since been extended to serve 300 000 people. The works consist of four supply mains, two receiving wells, six slow sand filters and two filtered-water basins.

On reaching the water-works at Nogiyama the raw water is discharged into two small receiving wells of masonry construction, and from these is delivered onto the slow sand filters. The receiving wells are too small to be of any benefit as settling basins. It is furthermore claimed that settling basins are unnecessary owing to the comparativ clearness of the raw water except during the rainy seasons of June, July and August. Suitable regulating devices are provided to maintain a constant water level in the receiving wells and on the filters.

The three filters bilt some 24 years ago when the first pipe lines were laid from Fujiyama have in recent years been supplemented by three more filters. These beds are arranged in two batteries, one of four and one of two filters. The former are each 120 by 70 ft., and the latter are each 120 by 80 ft., corresponding to a total filtering area of 1.212 acres. The tanks are bilt of masonry and faced with brick. The effluent collecting system is quite

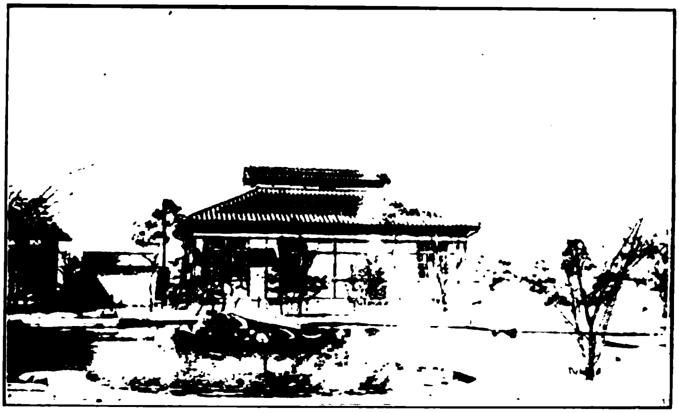

Fig. 1.—Laboratories. Osaka Water-Works, Japan.

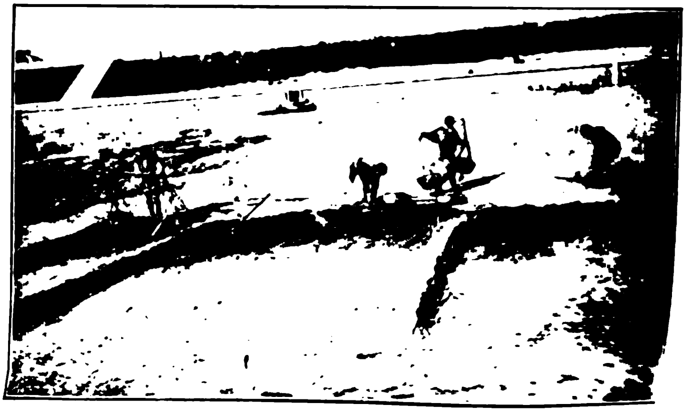

Fig. 2.—Osaka Water-Works, Japan. Bed from which Sand Layer is Being Removed on Account of Deep Clogging. Settling Basins in Background.

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similar to that in the Tokyo filters, except that over the floor of the filter tank the two layers of brick are laid flat instead of on the side. The layer of graded underdraining material is 18 in. thick and supports the filter proper composed of 30 in. of medium sized sand. This sand is obtained from the beach and is rather dark in color, but apparently of good stable quality. It costs about $2.75 per cu. yd. in the filters, a somewhat high figure for filter sand in Japan, and made so by the expense of transportation from the beach up the hill to the works.

The filters are operated at the rate of about 6½ million gal. per acre daily, a figure considerably in excess of ordinary practis elsewhere. The sand surfaces require scraping about once a month on an average, the period between such scrapings being materially shorter during the rainy seasons. Methods of sand washing are similar to those employed at Tokyo.

The filtered-water reservoirs are both covered with wooden bildings about 3 ft. high at the eaves, and are well baffled to prevent stagnation. Their total capacity is about 3.2 million gal., corresponding to about 12 hr. supply.

The filtered product is clear, soft and practically colorless and stands in enviable repute among the citizens of Yokohama. The works are well bilt and operated. There are at present 2 700 metered and 7 700 unmetered services, and over 1 200 fire hydrants. The daily consumption ranges from 19 to 29 and averages 24 gal. per capita. The total cost of the works at the close of 1906 was about $1 550 000.

The Chief Engineer and Superintendent of the Yokohama waterworks is Mr. Zentaro Mita.

THE OSAKA WATER-WORKS.

Osaka, the leading commercial center of Japan, is located at the northern extremity of the Izumi Sea and has a population of over 1 250 000 people. The existing water-works were put under construction in 1892 and were designed to serve a population of 800 000 people. The works have been extended from time to time but frequently are unable to supply the demand.

The source of supply is the Yodo River from which the water is raised by three centrifugal pumps into a series of settling basins against a total head of about 30 ft. After about 30 hr. sedimentation the clarified water is applied to slow sand filters, and then pumpt by seven triple-expansion pumping engines of the Worthington type to the distributing reservoir at Osaka Castle against a total head of about 130 ft. The delivery to the consumers is entirely by gravity.

The character of the raw Yodogawa water is not unlike that of many American rivers. The turbidity ranges from 10 to about 350 parts per mil., and in an average year there will be about 20 days when the turbidity will be over 100 parts per mil. and about 50 days when it will be over 50 parts. The alkalinity averages about 20 parts per mil., and the numbers of bacteria range from 40 to 30 000, and average about 2 000 per cu. cm.

Well-equipt chemical, bacteriological and cement-testing laboratories are maintained by the city at the water-works, and systematic analyses of the raw and filtered water are made daily by trained analysts whose methods as a rule are well up to date.

The settling basins are arranged in series, are five in number and are uncovered. They are each 330 by 360 by 12 ft. effectiv depth (the actual depth is 15 ft.) and have a combined capacity of about 53 million gal.

The sediment is flusht from these basins about once a year when on an average about 4 in. are removed. It is said that the cost for labor in removing this deposit amounts to about 2 cents per cu. yd.

The cost of construction of the basin completed in 1903, the effectiv capacity of which is about 10 million gal., was $83 370, exclusiv of the cost of land, the present cost of which is in the neighborhood of $2 500 per acre. It is significant how closely these construction cost figures approximate American practis.

The filters are of the slow sand type and eleven in number. Ten of these beds are 151 by 182 ft. in area and one is 182 by 350 ft. in area, making a total filtering area of about 7¾ acres. The filter tanks are bilt of concrete and brick, and the system of effluent collectors does not differ from that in the Tokyo filters. Over the brick underdrains is placed a layer 1½ ft. thick of coarse, well-graded underdraining material, which supports a layer of coarse and fine sand 2½ ft. in thickness.

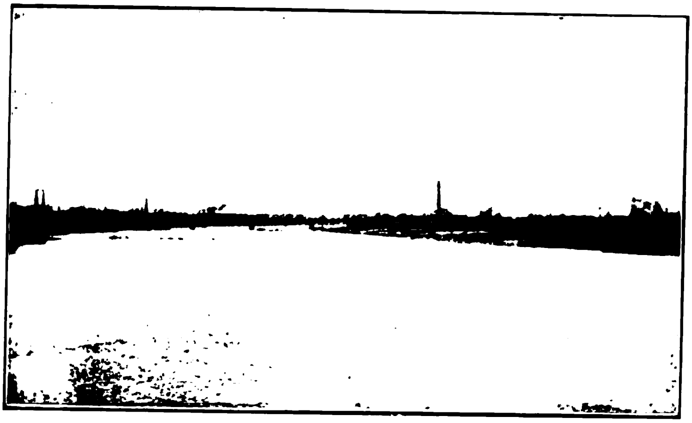

FIG. 1.—VIEW UP THE YODO RIVER. OSAKA WATER-WORKS IN BACKGROUND IN RIGHT CENTER.

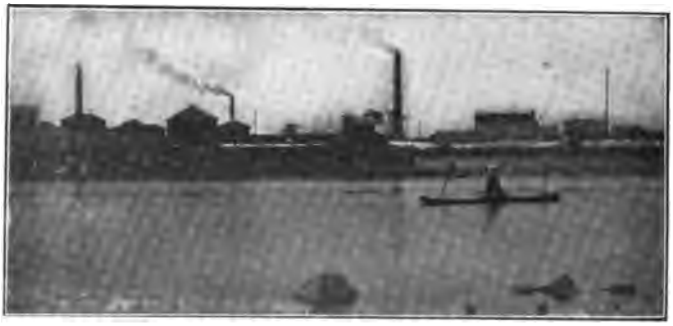

FIG. 2.—COOLIE DREDGING SAND BY HAND FROM THE YODO RIVER FOR OSAKA WATER-WORKS.

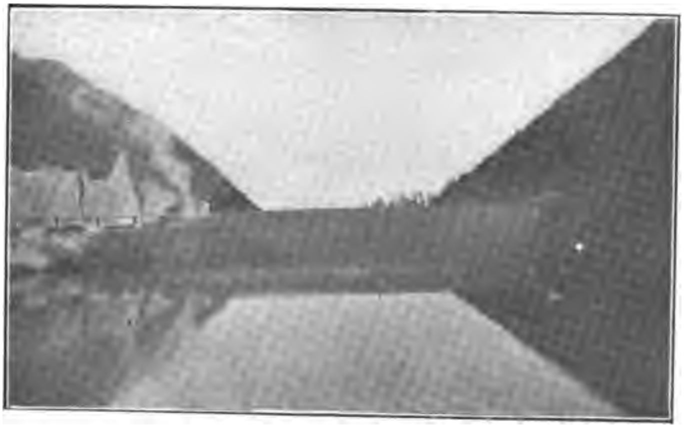

FIG. 3.—IMPOUNDING RESERVOIRS FOR KOBO WATER-WORKS, JAPAN.

The filter, finisht in 1903, 182 by 350 ft. by 7.5 ft. deep, cost $40 700 or $27 840 per acre, exclusiv of filtering material, which cost about $3 000 more per acre. This figure for sand is comparable with costs in some American cities, but considerably lower than the average in this country. The construction cost is easily comparable with the best American practis.

The filters are operated generally in an up-to-date manner, altho the rate of filtration is not automatically controlled, but fluctuates with the pumpage. There is only a small basin at the works, virtually a pump well, for storing the filtered water. The average rate of filtration is slightly less than 3 million gal. per acre daily and the net yield of the filters averages about 2.6 million gal. per acre daily.

Each filter requires scraping at about bi-weekly intervals. From November to May the beds are scrapt once a month, and from June to October about three times a month. The scrapers receive 20 cents per day of 9 hr., and the coolies who carry the scrapings from the beds in baskets receive 17.5 cents per day. No attempt is made to recover the sand removed from the beds during scraping, the dirty sand being used largely for fill. In consequence of this a gang of coolies is kept busily engaged practically all of the time dredging sand by hand from the bed of the Yodo River, and bringing it to the shore in boats, where it is sun dried and pan-screened.

The filtered water, as shown by very numerous daily analyses, is of excellent quality. During an average year the water delivered to the consumers contained an average of 25 bacteria per cubic centimeter.

Charges for water vary from 10 cents to 60 cents per 1 000 gal., the average being about 20 cents. There are at present over 49 000 services of which about 10 000 are metered. There are about 3 000 fire hydrants. The total cost of the works at the close of 1906 was about $1 650 000.

Until quite recently the Chief Engineer of Osaka was Mr. K. Funabiki, the water-works coming under his charge.

THE KOBE WATER-WORKS.

Kobe is located at the entrance to the inland sea at the foot of a steep mountain slope. Next to Yokohama this is the most important seaport in Japan, serving as it does as the sea outlet for the city of Osaka. It has a population of about 300 000.

The water-works at Kobe were put under construction in 1897 and were designed to serve a population of 250 000. They consist of impounding reservoirs in the hills immediately back of the city, slow sand filters and small distributing reservoirs.

The impounding reservoirs, two in number, have a total capacity of 483 million gal., corresponding to a storage of 54 days' supply at a daily average rate of consumption of 9 million gal. The catchment area for the most part consists of the steep slopes of the hills back of the city, two small brooks serving as the main feeders of the reservoirs. The water-shed is but sparsely populated owing to its extremely mountainous character.

On account of the long period of storage allowed, the raw water is never excessivly muddy as supplied to the filters. It is soft, as is true of the majority of Japanese waters, and usually is free from noticeable amounts of color.

The filters are eleven in number and have a total area of about 3 acres. Prior to filtration the water passes thru a supply basin having a capacity of 1 million gal. Details of construction and cost of these filters do not differ radically from those noted in the case of the Osaka filters.

The distributing basins are five in number and have a total capacity of 260 000 gal. There are upwards of 12 000 services in the city, about one-quarter of which are metered. There are about 1 200 fire hydrants.

The daily consumption ranges from 20 to 40 and averages 30 gal. per capita daily. The total cost of the system at the close of 1906 was about $1 470 000.

THE NAGASAKI WATER-WORKS.

The Nagasaki water-works were put under construction in 1889, and consist of impounding reservoirs, slow sand filters and distributing reservoirs. It is a gravity system thruout. The original works were designed to serve a total population of 60 000, but have since been extended to serve 182 000. The population of Nagasaki is now about 160 000.

PLATE 73.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
JOHNSON ON MUNICIPAL WATER-
WORKS OF THE FAR EAST.

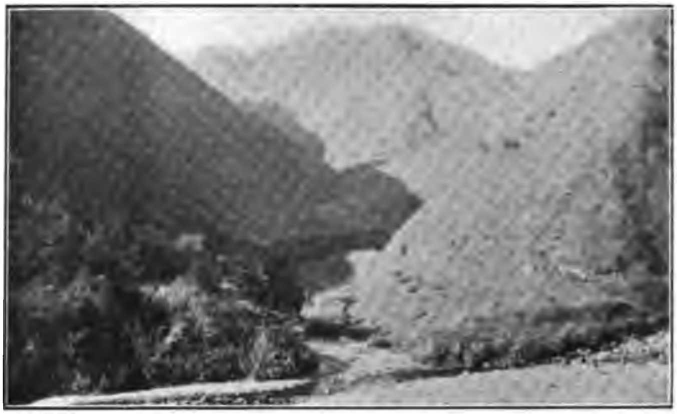

FIG. 1.—TYPICAL VIEW OF WATERSHED, KOBO, JAPAN.

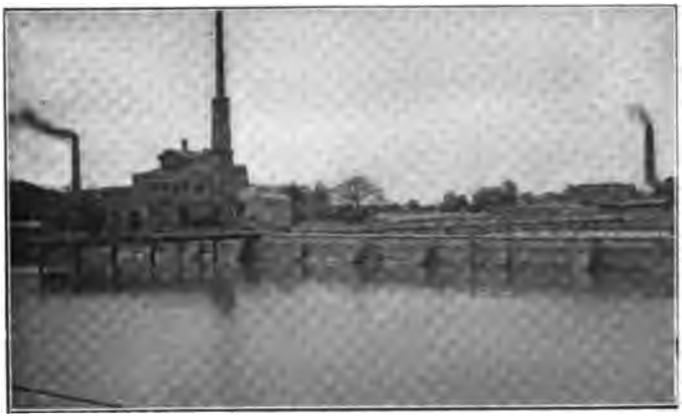

FIG. 2.—SETTLING BASINS FOR SHANGHAI WATER-WORKS, CHINA.

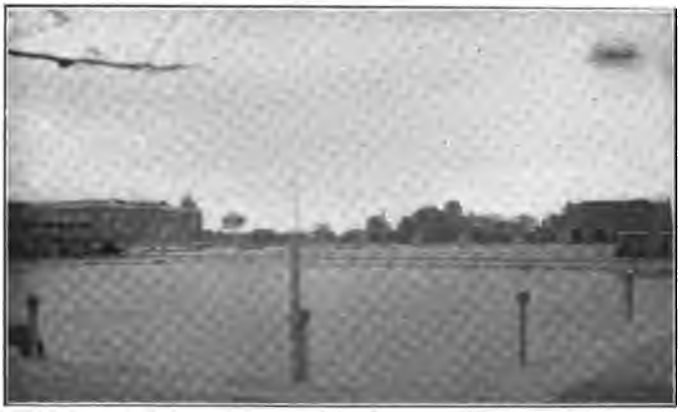

FIG. 3.—SLOW SAND FILTERS FOR SHANGHAI WATER-WORKS, CHINA.

The supply is derived from small mountain streams and is impounded in three reservoirs having a total capacity of 493 million gal., or sufficient for over 100 days' supply.

The filters are nine in number, all of the slow sand type, and have a total area of about 2½ acres. The clear-water reservoirs are four in number and have a total capacity of about 2.9 million gal. From these reservoirs the water flows by gravity to the city.

There are 5 900 services in the distribution system about 1 000 of which are metered. There are also about 500 fire hydrants. The total cost of the system at the close of 1906 was about $790 000.

THE WATER-WORKS OF HIROSHIMA, SHIMONOSEKI, AKITA, HAKODATE, IIZUKA AND KAMIURA.

The following notes will serve to give the main features of the water-works of the above-named cities and towns.

Hiroshima.—Construction work was begun in 1896. Population in 1904 was 127 117. The works were designed to serve a population of 120 000. The source of water supply is the Ota River. There are two settling basins with a total capacity of 1.2 million gal. The slow sand filters, four in number, have a total area of 1.75 acres. The clear-water basins, two in number, have a total capacity of 950 000 gal. Water consumption ranges from 15 to 40 and averages 28 gal. per capita. There are at present 6 693 services in the city, 1 610 of which are metered. There are 709 fire hydrants. The total cost of the system at the close of 1906 was about $465 560.

Shimonoseki.—Construction work was begun in 1900. Population in 1904 was 46 905. The works were designed to serve a population of 60 000. The supply is derived from small mountain streams. The impounding reservoir has a capacity of 286 million gal. There are three slow sand filters with a total area of 0.87 acre. There are two clear-water basins with a total capacity of 270 000 gal. Distribution is by gravity. Total cost of the works at the close of 1906 was $449 080.

Okayama.—Construction work was begun in 1900. Population in 1904 was 81 324. The works were designed to serve a population of 80 000. The source of supply is the Asahi River. There are two settling basins with a total capacity of 3.09 million gal. There are four slow sand filters with a total capacity of 810 000 gal. The total cost of the system at the close of 1906 was about $401 900.

Akita.—Construction work was begun in 1903. The population in 1904 was 33 695. The works were designed to serve a population of 40 000. The source of supply is drawn from the Asahi River, a branch of the Omono River. The settling basin has a capacity of 1.09 million gal. There are two slow sand filters with a total area of 0.66 acre. The capacity of the clear-water basin is 750 000 gal. The total cost of the system at the close of 1906 was about $235 150.

Hakodate.—Construction work was begun in 1898. Population in 1904 was 88 071. The works were originally designed to serve a population of 60 000, but have since been extended to serve a population of 150 000. The supply is drawn from the Aka River. The storage reservoir has a capacity of 1.53 million gal. The water is not filtered. There are two distributing reservoirs, the total capacity of which is 1.92 million gal. The daily water consumption ranges from 22 to 35 and averages 26 gal. per capita. There are at present 2 509 services in the city, 729 of which are metered. There are 410 fire hydrants. The total cost of the works at the close of 1906 was about $229 310. This city was destroyed by fire in 1907.

Sawarazawa.—Construction work was begun in 1898. Population in 1904 was 1 396. The works were designed to serve a population of 1 229. The supply is drawn from small mountain streams. The impounding reservoir has a capacity of 300 000 gal. The water is distributed by gravity direct from this reservoir to the consumers. The total cost of the works at the close of 1906 was about $5 060.

Iizuka.—Construction work was begun in 1898. Population in 1904 was 1 240. The works were designed to serve a population of 1 085. The supply is drawn from mountain streams. The impounding reservoir, from which the water is distributed direct by gravity to the consumers, has a capacity of 200 000 gal. The total cost of the works at the close of 1906 was about $3 410.

Kamiura.—Construction work was begun in 1900. Population in 1904 was 2 165. The works were designed to serve a population of 2 500. The source of water supply is the Ushimaki River. The

PLATE 74.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
JOHNSON ON MUNICIPAL WATER-
WORKS OF THE FAR EAST.

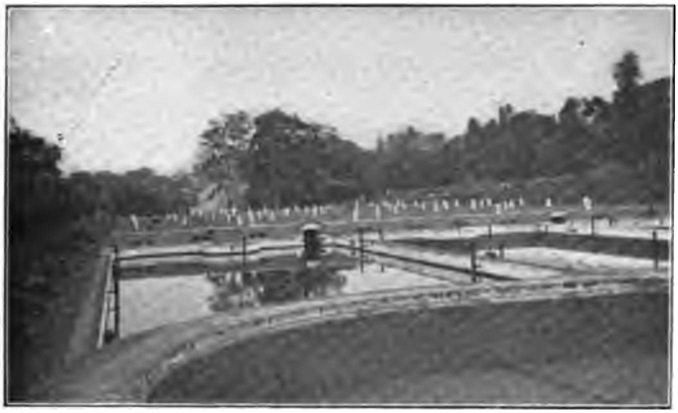

FIG. 1.—FILTERS AND CLEAR WATER BASIN, SINGAPORE, STRAITS SETTLEMENTS.

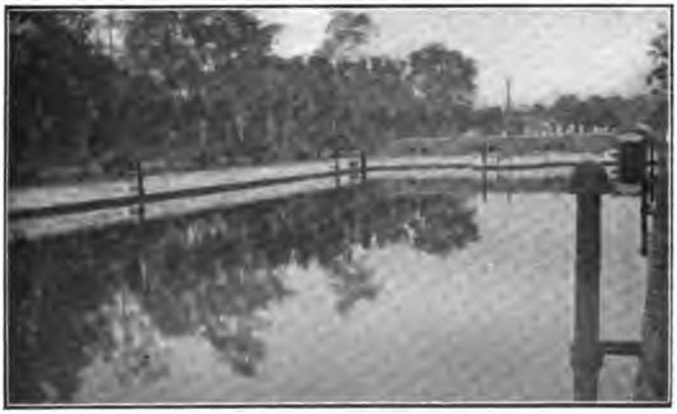

FIG. 2.—FILTERS IN OPERATION, SINGAPORE, STRAITS SETTLEMENTS.

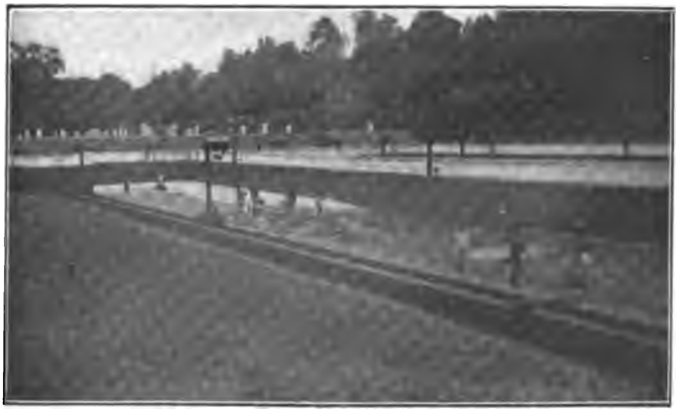

FIG. 3.—SCRAPING A FILTER AT SINGAPORE, STRAITS SETTLEMENTS.

water is supplied directly to a small sand filter (area 0.017). The clear-water basin has a capacity of 22 000 gal. The total cost of the works at the close of 1906 was about $3 410.

The Shanghai Water-Works.

Shanghai is located on the east coast of China, south of the Yellow Sea and near the mouth of the Yang-tse-Kiang, and has a population of about 600 000. The Shanghai water-works were bilt for the particular purpose of furnishing with pure water the residents of the city who are of foren birth. In round numbers 45 000 people are supplied by these works, of which some 12 000 are of English and American birth and the remainder high-class Chinese.

The rivers of Eastern China are almost always badly polluted and heavily charged with yellow clay. The Hwang-po, from which Shanghai draws its supply, is no exception to this rule. These river waters carry in suspension so much of this yellow clay that the ocean for as much as a hundred miles from the mainland is colored a deep yellow. It was from this phenomenon that the Yellow Sea derived its name.

The raw water is raised from the river by two centrifugal pumps of local make into settling basins which allow of a period of subsidence of about 25 hours. The clarified water is supplied to slow sand filters, of which there are twelve, varying in area from $\frac{1}{18}$ to $\frac{1}{3}$ acre. Considerable fine clay still remains in suspension even after 25 hr. subsidence, and the filters require scraping at intervals of once a month or less. There seems to be little dout that a coagulant could be used to good advantage at this plant to facilitate subsidence of the suspended matter which the raw water contains. Such treatment would unquestionably lessen the load on the sand filters and extend materially the period between obligatory scrapings.

Passing the filters the water flows to a clear-water basin having a capacity of about 6 million gal. and is then pumpt directly to the consumers thru two 20-inch mains. The daily pumpage ranges from 5 to 7 million gal.

Construction work in this plant is of a high order of excellence, and the operating procedures are as good as the somewhat unfavorable conditions will permit. The chief trouble with this plant seems to be that insufficient attention is given to the preparation of the water for filtration.

THE SINGAPORE WATER-WORKS.

The city of Singapore is located on the iland of Singapore at the southern extremity of the Malay Peninsula, and has a population of about 200 000. The water supply is derived from small jungle streams and while not particularly turbid is highly colored much of the time as would be expected, and possesses markt tastes and odors.

The water is impounded in a 1 000 million gal. reservoir located on Thomson road just outside the city. From this reservoir the water flows by gravity to the filters, which are located on the outskirts of the city.

The filters are of the slow sand type, eight in number, and have a total filtering area of about 2 acres. The water is double filtered and operation is intermittent; that is, the beds are allowed to rest empty about 12 hours in every one to two weeks, according to the degree of success attending the removal of the objectionable tastes and odors from the water. The actual rate of filtration is said to be about 1 million gal. per acre daily, corresponding to a net yield for the plant of about 2 million gal. daily. The average daily consumption is said to be about 5 million gal., so it would appear that less than half the supply is actually filtered.

It is understood that by intermittent operation of the filters a considerable degree of success has been achieved in removing the objectionable tastes and odors from the water, altho at the time of the writer's visit to the works, in July, 1906, the filtered water had a very markt "fishy" odor which was rather objectionable.

THE WATER-WORKS AT BETMANGULA.

At the time of the writer's tour of the world, the first mechanical filter plant encountered was the one at Betmangula which was constructed in 1903-04 by the Jewell Export Filter Company. The greater portion of the filtered water goes to the Kolar Gold Fields and the balance to the small town of Robertsonpet. The plant is located just outside the village of Betmangula and about 7 miles

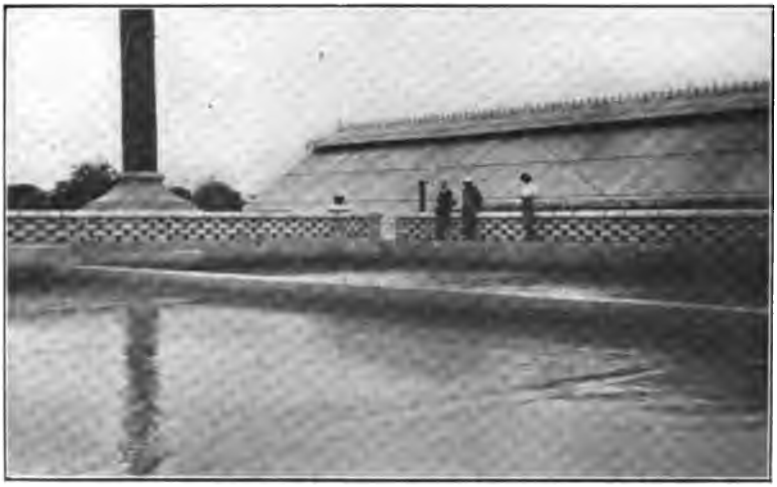

FIG. 1.—COAGULATING BASIN OF FILTER PLANT FOR KOLAR GOLD FIELDS AT BETMANGULA, INDIA.

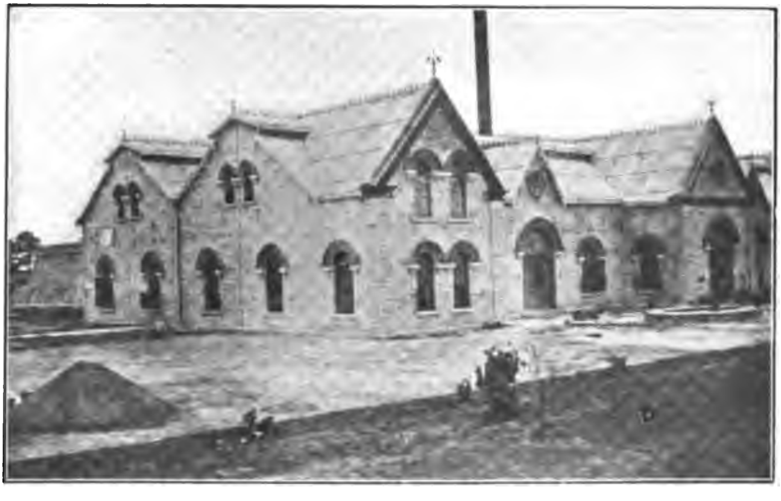

FIG. 2.—FILTER HOUSE FOR PLANT FOR KOLAR GOLD FIELDS AT BETMANGULA, INDIA.

from the gold fields. Up to the time the present works were installed, the water supplied to the laborers at the mines was not only of extremely poor quality but often deficient in quantity. The laborers at the mines are chiefly nativs, altho among the 20 000 workers there are about 800 English miners.

The supply is taken from the Palar River, upon which the large storage reservoir at Betmangula, together with many similar reservoirs, or tanks as they are called locally, is located. The capacity of this reservoir is about 1 725 million gal., sufficient at present for over 700 days supply. The rainfall in this section of India averages about 17 inches annually, and occurs in a very limited period of the year. The raw water is deeply colored and during the short rainy season is very muddy.

The raw water flows by gravity from the storage reservoir to a suction well adjacent to the filter bilding and from there is raised into the coagulating basin by two low-lift pumps. Sulfate of alumina is supplied to the water as it enters a continuous-flow coagulating basin wherein a period of subsidence of about 4 hr. is allowed. The clarified water leaves the coagulating basin over outlet wiers and is then delivered to the filters. Passing the filters it is discharged thru Weston rate controllers into a flume leading to a clear-water basin, from which it is pumpt to the gold fields thru a 16-in. force main against a total head of about 500 ft.

The coagulating basin is uncovered, is bilt of granit masonry, and lined inside with brick coated with "surki" mortar. It is divided into two compartments by a party wall, and has a total capacity of about 400 000 gal. The floor of the basin is of concrete.

The filters are four in number, are of the Jewell gravity type, circular in plan and bilt of concrete. Over the manifold collecting system a thin layer of gravel is placed, which supports 3½ ft. of fine sand. Each filter has a rated capacity of 620 000 gal. per 24 hr.

The clear-water basin is located below ground level outside the filter bilding, and is covered. The basin is bilt of masonry.

The two low-lift pumps have a total capacity of about 5.3 million gal. per 24 hr., and the three Worthington high-lift pumps have a capacity of 3.6 million gal. per 24 hr. The centrifugal washwater pump has a capacity of 2 000 gal. per min. and is belt-driven by a Pelton wheel, operated with water from the 16-in. high-pressure main. Steam to operate the high and low-lift pumps is supplied by two 225-hp. Babcock & Wilcox boilers.

Since the works were completed periodic analyses of the raw and filtered water have been made by the official bacteriologist of the Mysore government, and always show the purified water to be high grade. Cholera was very prevalent among the workers at the mines prior to the installation of this plant, but since that time has virtually disappeared. The plant is excellently constructed and is operated in a most intelligent and efficient manner.

THE CALCUTTA WATER-WORKS.

Calcutta, the capital of British India, is located in the Province of Bengal on the right bank of the Hugli River and about 45 miles inland from the Bay of Bengal, and has a population of about 1 200 000.

The original works were put under construction in 1867, greatly enlarged in 1886 and now consist of two pumping stations, settling reservoirs, slow sand filters, gravity condits and a reservoir on the outskirts of the city. Auxiliary pumps at this point force water direct to the consumers in the northern part of the city, the remainder being delivered into three reservoirs, one in the suburbs and two in the town, from each of which it is again pumpt to the consumers. The occasion for so much pumping is that the site of the city is practically on a dead level.

The Hugli River, from which the water supply is taken, is the most western branch of the Ganges. The drainage area amounts to about 25 000 sq. miles, altho in addition to the run-off of this area considerable excess flow from the Ganges finds its way into the Hugli during the rainy season of July, August and September thru the Bhagirathi, Jellinghi and Matabanga Rivers, which connect the Ganges and the Hugli above Palta, where the intake is located.

Even in the dry season the waters of the Hugli are very muddy, becoming excessivly so during the rainy season, a fact not to be wondered at when it is understood that of the 60 in. which constitutes the average annual rainfall, as much as 40 in. has fallen in a single week, and as much as 10 in. in one day is by no means unusual.

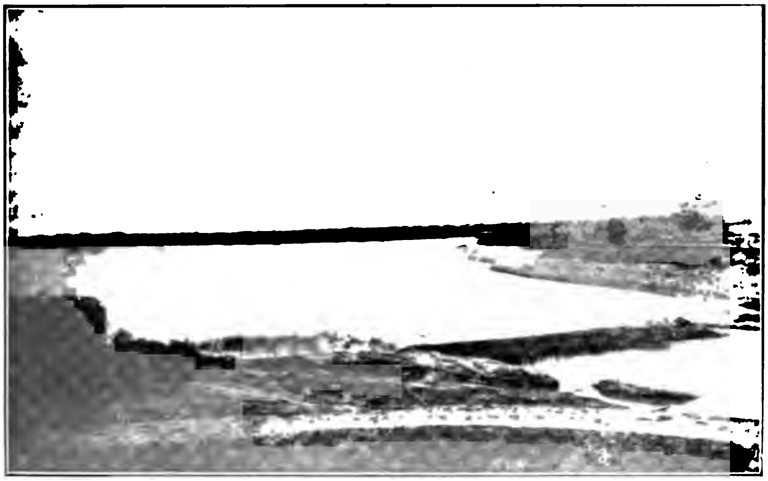

FIG. 1.—IMPOUNDING RESERVOIR FOR KOLAR GOLD FIELDS AT BETMANGULA, INDIA.

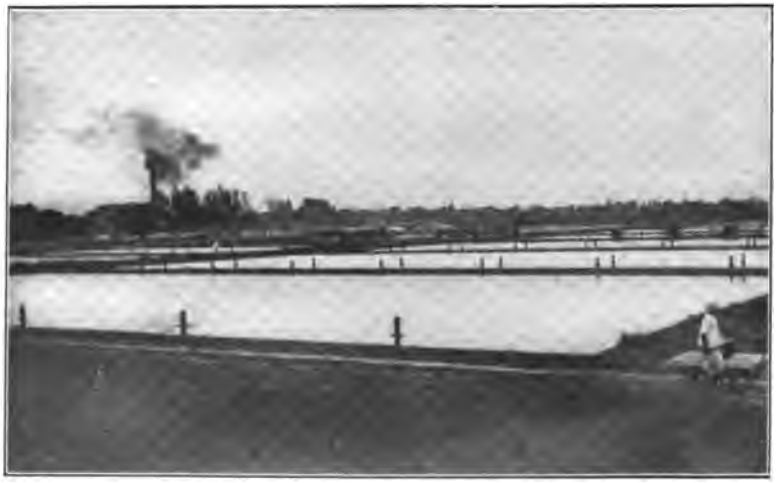

FIG. 2.—GENERAL VIEW OF FILTERS FOR WATER-WORKS AT CALCUTTA, INDIA.

The water at Palta, 16 miles above the city, is subject to tidal influences; in fact the rise and fall of the tide is felt 75 miles above this point. From February to June, the dry season, the water at the Palta intake is decidedly brackish for a considerable part of every day which makes it necessary to pump intermittently, and to operate the settling basins on the fill and draw plan.

Six of the settling basins are of masonry and were bilt during the years immediately following 1867. Each of these basins is 500 by 250 ft. and 7 to 9 ft. in depth. The total capacity of the six basins is 21 million gal. About 15 years ago four more basins were bilt. These are merely earth excavations in sandy clay, puddling being practically dispensed with. They are all remarkably tight, however. Two of these basins are each 2 500 by 350 by 9 ft. deep, the dimensions of the remaining two basins being 2 500 by 250 by 9 ft. deep. The total capacity of these four basins is therefore 84 million gal., making the grand total capacity of all ten basins 105 million gal. As the basins are workt on the fill and draw plan, the period of sedimentation is variable.

During the rainy season of July, August and September, the raw water is treated with about 2 grains per gal. of alumino-ferric as it enters the basins. This chemical costs about $20.50 per ton delivered at the works.

The original works included 12 slow sand filters, and since that time 24 more filters have been bilt. These beds are 200 by 100 ft., corresponding to about 16.5 acres total filtering area for the 36 filters. The effluent collectors consist of small cross-drains covered with tiles which discharge into the main collecting channels laid along the center of the filters, which deliver the effluent into collecting wells, from which it flows directly into two condits, 4 and 3.5 ft. in diameter, respectivly, leading to the auxiliary pumping station in the outskirts of the city 12.5 miles distant. The three effluent collecting wells have a total capacity of 42 000 gal. It is the present custom to supply filtered water to the entire city under about 30 lb. pressure during the day hours, excepting between 10 A. M. and 3 P. M., during which hours the water is supplied under low pressure only to the more thickly populated sections of the city.

A complete separate system for unfiltered water is provided for street-sprinkling, sewer-flushing and fire-extinguishing purposes.

TABLE No. 1.—FIGURES ON POPULATION IN 1904.

City or town.	Date of commencement of construction.	Number of houses.	Number of people per house.	Total population.
Tokyo	1891	433 272	4.3	1 870 628
Osaka	1892	238 969	4.3	1 026 767
Yokohama	1885	64 029	5.2	331 597
Kobe	1897	75 151	4.0	297 276
Nagasaki	1889	22 005	7.2	159 041
Hiroshima	1896	29 181	4.4	127 117
Shimonoseki	1900	15 184	3.2	46 905
Okayama	1900	13 818	5.9	81 324
Akita	1903	7 521	4.5	33 695
Hakodate	1898	21 911	4.0	88 071
Sawarazawa	1898	170	8.2	1 396
Iizuka	1898	156	7.9	1 240
Kamiura	1900	433	5.0	2 165

TABLE No. 2.—FIGURES ON POPULATION AT TIME PLANT WAS DESIGNED.

City or town.	Number of houses.	Number of people per house	Total population.	Population which plant was designed to serve.
Tokyo	279 000	4.3	1 200 000	1 500 000
Osaka	95 687 194 084*	5.0 4.4	476 392 849 171*	600 000 800 000*
Yokohama	10 294 29 051*	6.0 6.0	63 000 174 303*	70 000 300 000*
Kobe	35 941	3.9	141 394	250 000
Nagasaki	6 753 16 559*	6.7 6.8	44 921 113 307*	60 000 183 000*
Hiroshima	25 866	3.2	84 088	120 000
Shimonoseki	7 565	5 6	42 063	60 000
Okayama	11 989	5.3	64 170	80 000
Akita	7 155	4.4	31 584	40 000
Hakodate	10 417 14 152*	4.6 4.5	48 366 63 619*	60 000 150 000*
Sawarazawa	159	7 7	1 229	1 229
Iizuka	152	7.1	1 085	1 085
Kamiura	455	5.1	2 305	2 500

* At time of extension of works.

TABLE No. 3.—DATA RELATIV TO SERVICES.

City or town.	Total Number of services.	Number of fire hydrants.	Number of houses having services.	Number of unmetered services.	Number of metered services.
Tokyo	85 589	5 177	167 689	59 848	20 514
Osaka	48 518	3 000	140 905	36 141	9 369
Yokohama	11 600	1 236	31 610	7 679	2 745
Kobe	11 581	1 178	22 674	7 882	2 576
Nagasaki	5 901	492	16 891	4 456	953
Hiroshima	6 698	709	19 678	4 374	1 610
Shimonoseki	.....	.....	......	......	......
Okayama	.....	.....	......	......	......
Akita	.....	.....	......	......	......
Hakodate	2 509	410	21 911	1 370	729
Sawarazawa	.....	.....	170	23	......
Iizuka	.....	.....	156	30	......
Kamiura	.....	15	447	20	......

TABLE No. 4.—DATA RELATIV TO WATER CONSUMPTION.

City or town.	Per capita consumption as estimated at time of construction.	TOTAL ACTUAL CONSUMPTION. MILLION GALLONS PER DAY.			ACTUAL PER CAPITA CONSUMPTION. GALLONS PER DAY.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Tokyo	28.4	34.10	16.75	24.20	22.7	11.2	17.0
Osaka	23.4 22.4*	23.80	12.84	19.80	29.7	16.0	25.0
Yokohama	21.6 21.6*	6.94	4.55	5.58	29.4	19.2	23.8
Kobe	22.5	4.71	2.26	3.48	39.7	20.0	30.3
Nagasaki	24.0 22.5*	2.98	0.84	1.08	......	......	......
Hiroshima	18.7	3.96	1.21	2.61	40.0	14.4	27.8
Shimonoseki	22.5	......	......	......	......	......	......
Okayama	22.5	......	......	......	......	......	......
Akita	18.4	......	......	......	......	......	......
Hakodate	18.1 19.5*	3.10	1.99	2.26	35.2	23.5	25.6
Sawarazawa	11.9	......	......	......	......	......	......
Iizuka	11.9	......	......	......	......	......	......
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Nagasaki	5 901	492	16 891	4 456	958
Hiroshima	6 693	709	19 673	4 874	1 610
Shimonoseki	.....	.....	......	......	......
Okayama	.....	.....	......	......	......
Akita	.....	.....	......	......	......
Hakodate	2 509	410	21 911	1 370	729
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City or town.	Per capita consumption as estimated at time of construction.	Total Actual Consumption. Million Gallons per Day.			Actual per Capita Consumption. Gallons per Day.		
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Kobe	22.5	4.71	2.26	3.48	39.7	20.0	30.3
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Shimonoseki	22.5	......	......	......	......	......	......
Okayama	22.5	......	......	......	......	......	......
Akita	18.4	......	......	......	......	......	......
Hakodate	18.1 19.5*	3.10	1.99	2.26	35.2	23.5	25.6
Sawarazawa	11.9	......	......	......	......	......	......
Iizuka	11.9	......	......	......	......	......	......
Kamiura	21.6	......	......	......	......	......	......

* At time of extension of works.

TABLE No. 5.—SOURCE AND TREATMENT OF WATER SUPPLY.

City or town.	Source of Supply.	Impounding reservoirs capacity in mil. gals.	Capacity of settling reservoirs in mil. gals.	Total Area of filter beds in acres.	Capacity of filtered water reservoir in mil. gals.
Tokyo	Tama River.	None	(3) 66.20	(18) 17.50	(6) 22 10
Osaka	Yodo River.	None	(5) 51.50	(11) 7.61	(3) 5.19
Yokohama	Doshi River.	None	0.54	(8) 1 42	(3) 6.83
Kobe	Impounding Reservoir.	(2) 188.0	1.00	(11) 3.04	(5) 0.26
Nagasaki	Impounding Reservoir.	(3) 196.9	None	(9) 2.36	(4) 2.98
Hiroshima	Ota River.	None	(2) 1.20	(4) 1.75	(2) 0.95
Shimonoseki	Impounding Reservoir.	286.0	None	(3) 0.87	(2) 0.27
Okayama	Asahi River.	None	(2) 3.09	(4) 1.31	(2) 0.81
Akita	Asahi River.	None	1.09	(2) 0.66	0 75
Hakodate	Asa River.	None	1.53	None	(2) 1.92
Sawarazawa	Impounding Reservoir.	0.3	None	None	None
Iizuka	Impounding Reservoir.	0.2	None	None	None
Kamiura	Ushimaki River	None	None	0.017	0.022

TABLE No. 6.—INITIAL COST OF CONSTRUCTION.

City or town.	Total.	Per capita.*
Tokyo	$4 250 000	$2.88
Osaka	1 658 020	2.07
Yokohama	1 548 140	5.16
Kobe	1 468 640	5.87
Nagasaki	788 080	4.33
Hiroshima	465 160	3.18
Shimonoseki	449 080	7.48
Okayama	401 900	5.02
Akita	235 150	5.88
Hakodate	229 810	1.53
Sawarazawa	5 060	4.11
Iizuka	4 090	3.79
Kamiura	3 410	1.86

* Based on the population to be served.

DISCUSSION.

Mr. Robert Ridgway.—The author, in his interesting paper, has carried us a long way from New York, but there ought to be some present who are prepared to discuss the subject. The paper is now open for discussion.

Mr. Ernest L. Mandel.—Mr. Chairman and Gentlemen: Before I received the official notice of this meeting, I thought Mr. Johnson would speak on Water Supplies in European Cities, and I took it for granted that he would not speak of the capital of my native country, Hungary. I have here a few notes, and, with your permission, I will read them:

Budapest has about 900 000 inhabitants and consists of the older City of Buda, and the newer City of Pest. Its water supply is one of the most perfect in Europe, both as to quality and quantity. Budapest is bilt on both sides of the river. The water supply system is arranged on the banks of the Danube and on some of the ilands. There are seventy-three wells sunk along the bank of the river. These wells cover a distance of about 8 miles, the average distance apart being about 600 ft. They are 10 ft. in diameter and about 50 ft. deep. The water is filtered by the natural method; that is, it goes thru a layer of gravel. All the wells are connected by pipes, and the driven wells that are located on the ilands are connected with the main pipe system by three tunnels, carried under the Danube at a depth of about 60 ft., thru hard, blue clay. These pipes discharge into a large reservoir, which supplies the city. The main pipes have a diameter of 48 in. The system is so perfect that in case there is any trouble in any portion of the city, water can be delivered there from another part of the system in about an hour. In its present condition the supply is about 240,000 cu. m.* per day, and the water consumption is 52 gal. per capita per day. I think in New York we consume about 125 gal. per capita per day. The temperature of the water is about 42° Fahr., only 10° above the freezing point. As to the quality, several thousand bacteriological experiments have been made and they showed that 1 c. c. of water contains about 28 harmless bacteria. Water can be considered safe if 1 c. c. contains less than 100 bacteria. As far as germs of typhoid are concerned, the experiments did not show any. The hardness of the water is 12.

Mr. Ridgway.—I am imprest with the low rate of per capita consumption as shown in the tables prepared by the author, and I would like to learn how he accounts for the difference between it and the average water consumption of our American cities.

Mr. Johnson.—I suppose that could be largely accounted for by the fact that a great many of the manufacturing establishments

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*Equivalent to about 63 million gallons.—*Ed.*

have their own water-works, and take unfiltered water from adjacent streams. Then there may be still another explanation; two more, as a matter of fact, for the low per capita water consumption there. One is, that they have very limited sewerage systems and therefore no water is used for sewer flushing. The other is their extremely economical use of water in the houses.

The Japanese method of bathing is rather unusual and is conducive to great economy in the matter of water consumption. The average Japanese takes a bath once a day. Each morning the bath is prepared in a tub and is as hot as is possible for a Japanese to get into, to say nothing of an Occidental. Immediately the Occidental gets into a hot bath, which is considered suitable for a Japanese, his skin turns red, and he wastes little time getting out while he can. The ordinary procedure for the Japanese family is to have this bath prepared each morning, when it is occupied first by the senior male member of the family, followed in succession by the other male members, without changing the water. Then the senior female member of the family takes her turn, and they go thru the list, to be followed by the servants. After this hot soak each person is splashed with cold water. There is undoutedly considerable economy of water here.

MR. DANIEL D. JACKSON.—I would like to ask Mr. Johnson whether the distributing reservoirs in Japan are covered.

MR. JOHNSON.—Yes, it is the rule, rather than the exception, in Japan to cover the distributing reservoirs.

MR. JACKSON.—When Dr. Nakajima, the Chief Engineer of Tokyo, was in this country he visited Mt. Prospect Laboratory and the first question he asked was, "Why are your distributing reservoirs not covered? They must be open to all sorts of microscopic growth." I said, "Well, it is pretty expensiv; we don't ordinarily cover our reservoirs here in this country very much, and on that account we are, in many cities, troubled by disagreeable tastes and odors in the water, which might be prevented by covered reservoirs." He remarked, "We in Japan find means to cover our distributing reservoirs. I think they should be covered in this country."

MR. NOAH CUMMINGS.—I would like to ask Mr. Johnson a question, altho it is not exactly about the water supply. I noticed in some of the pictures there were stone bildings. Of what kind of stone are the bildings constructed?

MR. JOHNSON.—Almost all granit. The prevailing stones are granit and sandstone.

MR. CUMMINGS.—The trees there do not grow very large, do they?

MR. JOHNSON.—Some of them do, one of them being of the Cryptomeria species, the best examples of which are found at Nikko. They are quite famous for their size and beauty.

Mr. Cummings.—They get all their lumber from their own country, do they not?

Mr. Johnson.—Yes.

Mr. Max L. Blum.—Mr. Johnson's tale of the Japanese method of using water reminds me of a plan which the New York *Times*, in all seriousness, states as being advanced for a certain Scotch city, Glasgow, I believe. It states that the proposition was advanced in the Municipal Council to collect all the waste water and refilter the same, *ad infinitum*, water being very expensiv in that city. A sort of creepy repugnance comes over one at the thought of using water that has already been in intimate contact with some of our fellow citizens of doutful personal habits, and I have been wondering whether the article in question was due to the inspiration of some journalist or not.

A Member.—I would like to ask whether they have any epidemics of disease in Japan, like typhoid fever.

Mr. Johnson.—Epidemics in Japan do not all emanate from water supplies. The habit of using human excrement for fertilizer undoutedly has as much, if not more, to do with the spreading of typhoid fever than anything else. All of the solid and liquid excreta is carefully preserved by each family and sold to contractors at so much per bucket. These contractors pay the Government a certain fee for license to collect this excreta and they, in turn, sell it to farmers for so much per bucket. I have seen and heard a great deal of argument on the part of the farmers as to whether the excreta they were buying was fully up to the standard and not too much diluted. This excreta is stored by the farmers in tanks at the fields, and from there is distributed onto the growing vegetables by means of buckets and small hand dippers. The coolie scoops up a bucketful of the excreta from the tank and walks down between the rows of growing vegetables, distributing dipperfuls of this material in a depression which is made in the ridge on which the vegetables are growing. I have repeatedly eaten vegetables there that I suspected tasted of human excrement. There cannot be any question of dout but that a great deal of typhoid fever is communicated in that way. As to other epidemics, of course they still have a great deal of plague and some cholera in Japan.

A Member.—I would like to ask Mr. Johnson whether that condition exists in the larger cities? Have they no sewers there at all?

Mr. Johnson.—Well, for the main part, only the larger cities are sewered outside of the foren concessions. Tokyo is the best off in this regard. I have explained how they take care of their so-called sanitary wastes. The kitchen wastes and other wastes from the houses are permitted to flow into the street gutters. These gutters are specially designed for carrying off these wastes, being rather deep and of considerable width. It is not an unusual thing to see children being assisted in their morning troubles by their parents at one point over these gutters and see housewives further down the gutters using the same water for washing up the breakfast dishes.

A **Member.**—How do you account for the cleanliness of the race?

Mr. Johnson.—Well, it is generally conceded that if a man takes a bath once a day he is tolerably clean. Now, by taking a very hot bath every day, followed by what virtually amounts to a cold shower, they really keep their person pretty clean. It is a fact that the Japanese have, to my nostrils, no body odor, a rather remarkable fact. The only odor about them that is particularly noticeable and somewhat objectionable is due to the brand of oil they use on their hair. They have professional hair-dressers there, and even the coolie women are not able to put up their own hair. They go once a week to a hair-dresser, and by making use of a pillow specially designed it is possible to keep the hair in good condition, that is to say, keep its shape in good condition for a week. In the meantime this oil has a tendency to grow rancid, thereby producing practically the only odor about a Japanese person that is noticeable.

Mr. George A. Taber.—Mr. Johnson has stated that the filter plant for the Kolar Gold Fields was constructed by the Jewell Export Filter Co. I would like to ask if all of the works which he has described to us to-night were, with this exception, constructed by nativ engineers, or whether any of them were bilt or designed by engineers of other countries?

Mr. Johnson.—So far as I know the Japanese works were all designed and constructed by nativs without exception. The Japanese engineer is a person who absorbs information very readily and it has become the custom in Japan to send representativs to this country and to all countries, to pick up the latest information on all important subjects. Dr. Nakajima, of whom Mr. Jackson has spoken, spent much time in this country studying water-works practises, and unquestionably this fact had much to do with the design of the Tokyo filters as they exist to-day. The Shanghai plant was designed and bilt by English labor; that is to say, the skilled labor was English, the nativ Chinese doing the manual labor. The Singapore works were designed, if my memory serves me correctly, by an Englishman, Mr. S. Tomlinson, a member of the American Society of Civil Engineers and a member of the Institution of Civil Engineers. The Calcutta works were also designed and bilt by Englishmen.

Mr. Ridgway.—On behalf of the Society, I want to thank Mr. Johnson for the instructiv and enjoyable evening he has given us, and for his patience in answering all of our questions.

WATERPROOFING—AN ENGINEERING PROBLEM.

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THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 44.

PRESENTED NOVEMBER 25, 1908.

WATERPROOFING—AN ENGINEERING PROBLEM.

BY MYRON H. LEWIS,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY

ROBERT RIDGWAY, GEORGE A. TABER, GARDNER L. VAN DUSEN, EDWIN H. THOMES AND THE AUTHOR.

INTRODUCTORY.

In presenting a paper on waterproofing before you this evening, I do so in the hopes of awakening a wider interest in this important and as yet ill-understood question, than the engineering profession has been accustomed to accord to it, and also to gather the experience of the members of the Society who have been engaged in waterproofing work, for it is to such exchanges of ideas that we must look for progress in this field. In no specialty of engineering work is there perhaps at the present time such a struggle between methods and materials, and such a chaotic condition of practis as here. This condition is a necessary result of the present transition stage of the waterproofing industry, and its attempt to catch up with the rapid development in kindred lines of construction work. In a large measure the laggardness in this field has been due to the absence of technical men in the business, and the consequent lack of any sort of reliable literature on the subject, and to other causes, to which I shall refer later.

---

*Assistant Engineer, Topographical Bureau, Boro of Queens.

It is only within the past few years that the increase in subsurface construction, and the consumption of cement in the bilding industry, have given a lively impetus to the development of waterproofing along scientific lines, and that the subject has been taken up by prominent technical bodies. The interest thus awakened, however, is advancing with a steadiness that leads us to hope for much more rapid progress in the future.

General Scope of the Subject.

We must, in the beginning, endeavor to define our subject, so that its limits will be clearly understood. This is a necessary precaution since most of the writers and advocates have fallen into the error of assuming that the particular method which they have to exploit covers the entire field. In its broad sense, "Waterproofing," as its name implies, is the rendering of materials or of structures immune from the action of water. "Waterproofing Engineering," then, is that branch of general engineering activity, which is devoted particularly to the means of protecting structures against the ravages of water in its discomforting or destructiv forms. It includes not only the methods of treating various substructural conditions, but also the treating of concrete to make it impermeable. It includes the treatment of the materials themselves, as well as of the structures composed therefrom, before or after erection, above or below ground, or in water. So also does its scope include a discovery of the causes and the remedies for objectionable conditions in bildings already erected, the prevention of decay and disintegration of structures, and structural materials. It is impossible in the course of an evening to go into every phase of this question, and I will limit myself particularly to masonry structures.

Taking waterproofing in this broad sense, we must realize that its general application must prove of great advantage to society, since its function is to greatly increase the life of those structures in which it is judiciously used, and what is of more importance, to secure to the dwellers therein immunity from the diseases which are fostered or spread by damp, clammy walls and the unwholesome conditions incident thereto.

NECESSITY OF WATERPROOFING.

It is scarcely necessary to dwell on the sanitary aspect of the question, since it is a fundamental principle of hygiene that dry habitations are necessary if we would enjoy the normal degree of health.

We paint our steel structures to prevent corrosion, but do we exercise a like care in seeking to protect the vast quanties of steel that enter the concrete of our modern structures. We paint the outside of our frame dwellings, for purposes of durability as well as beauty, but do we realize that for a trifling expense we can so treat the entire timber work of such dwellings as to effectually retard its decay. We take the precaution of draining our cellars into sewers, but with a singular inconsistency do we not often fail to protect them against becoming moisture-soaked and unsanitary? We expend large sums in the construction of costly reservoirs, tanks and dams, and frequently fail to take the precaution to conserve the water thus expensivly stored, as might be done by providing a water-tight enclosure, thus guarding at the same time against either a contaminating inflow, or a wasteful outflow?

We erect stately mansions of artistic designs, costly material and skilled workmanship, and before many years have past, their exterior beauty is frequently defaced by stains, or by the unsightly efflorescence, all of which is easily preventable if the simple expedient of waterproofing is adopted while the bilding is in the early stages of construction.

An impressiv illustration of the value of intelligent waterproofing is to be found in the modernly constructed bildings in the city of New Orleans, in which basements are being installed to a depth of 12 feet or more, where once this would have been considered impossible owing to its waterbearing soil and the absence of an adequate sewer system.

We install expensiv machinery in bildings equally expensiv, and too frequently this machinery becomes so clogged with rust, or in the case of electrical machinery becomes short-circuited, as to render its delicate parts unfit for use, so that its overhauling becomes a matter of necessity, even before it has ever served its purpose. Since rust is a result of moisture, and moisture may also

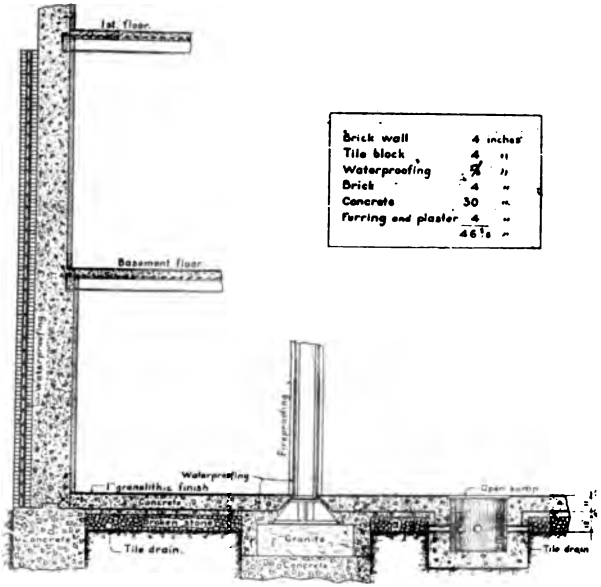

FIG. 1.—DESIGN FOR FELT WATERPROOFING IN PROMINENT NEW YORK BILDING. TOTAL THICKNESS OF WALL 46⅝ IN.; TOTAL THICKNESS OF FLOOR 16¾ IN.

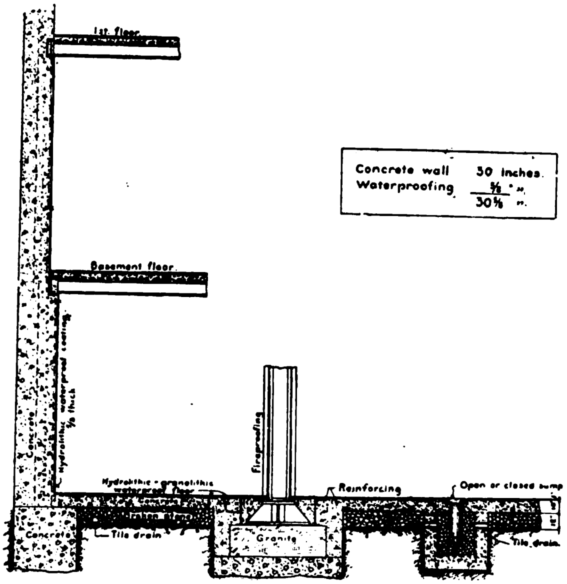

FIG. 2.—DESIGN FOR INTEGRAL METHOD OF WATERPROOFING IN SAME BILDING AS FIG. 1. TOTAL THICKNESS OF WALL 80⅝ IN.; TOTAL THICKNESS OF FLOOR 11 IN. BOTH WALLS AND FLOOR ARE MONOLITHIC.

be the cause of short circuiting, it follows that in a moisture-proof bilding no such conditions could occur.

We design and install elaborate sewer systems, the result of much study and deliberation, into which skilled engineers put their best thought. We spend thousands of dollars in providing efficient sewage disposal plants, but we often neglect to make the sewers water-tight, with the result that the pumping and disposal plants are burdened with the handling of ground water, which, in many cases, equals the entire volume of sewage flow, increasing the maintenance cost perhaps 25% or more.

We go to great expense in constructing refrigerating plants, but thru defectiv and leaky walls moisture finds its way, thus raising the temperature of the cooling rooms, after every effort has been made in other directions to keep it down.

We put up expensiv concrete superstructures, and it too often happens that lack of provision for waterproofing, or a defectiv system, causes the bilding to be unfit for occupancy, and entails upon the owner serious financial losses. We put up our bildings with all possible speed, in the hope of saving time and money, and before the walls have been given time to lose the large quantities of water stored up by rains or by water used during the construction period, we apply our paint to the outside, and plaster to the inside, only to find that from the pernicious activity of moisture first one and then the other begins to loosen, peel and go to pieces.

Often we take proper precautions to prepare our specifications, with a view of securing perfectly dry structures, and thru a false economy in the effort to select the lowest bids or thru inadequate supervision, we find the work which we expected to be perfect, turn out to be leaky and troublesome. Excavations must, therefore, he reopened, and the origin of the troublesome water traced to its hidden, and what sometimes seems undiscoverable source.

I could go on outlining such conditions which have in the past caused so much trouble, inconvenience and expense, and they are by no means visionary, but are gathered from actual occurrences, and I could point out to you the precise structure furnishing the example quoted in each case. If such conditions were the exception, and were met with but occasionally, we might be inclined to pass them by with an indifferent remark, but their continual recurrences bear me out in the assertion made at the outset, that the advantages and benefits accruing from waterproofing appear neither to be sufficiently understood nor appreciated by those who have in charge the planning and designing of construction work, and it is for this reason that I think it pertinent to call attention to them.

Causes for Neglected Condition of the Waterproofing Industry.

1st. Because there is almost a total lack of reliable and impartial literature on the subject.

2d. Because architects and engineers having often false impressions as to the immunity of structures from water penetration, and with a view of keeping down the cost have chosen to look upon the important item of waterproofing as a superfluity.

3d. Because those engaged in the waterproofing business are usually practical men, with but little desire to give to the public the benefit of their experience.

4th. Because of the unfortunate narrow policy hitherto followed by those in the waterproofing business, or by a large proportion of them. This policy has been not only narrow but obstructional in its results; narrow, because each concern has arrogated to itself a monopoly of the only successful methods of waterproofing known, and not even content with this, has taken the untenable position of disparaging and even denouncing as worthless the methods and materials of their competitors; narrow also because some of them have put forward their own materials and methods as infallible cures for all possible conditions, and make other extravagant and impossible claims, which instead of inspiring confidence and attracting support are rather calculated to awaken suspicion and distrust in the mind of the intelligent and critical purchaser.

We have long been accustomed to see printed in public advertizements that, "This compound is the only permanent and efficient waterproofing material known." And we have seen this statement so often that skepticism has developt into downright unbelief. We all of us realize that no individual firm enjoys a monopoly of the materials with which Nature has supplied us, and that to such a firm only is restricted the power to produce a material that is permanent and efficient. In my opinion such a policy could only react upon the industry in general, by causing a loss of confidence in the entire scheme, and, as a consequence, bring confusion and loss upon the people who had hoped to benefit by it.

At one meeting where there were five different papers read by as many representativs of waterproofing processes, each claimed to be the one and only correct exponent of what we may call waterproofing engineering. One of the ablest of these was by Mr. Edw. W. De Knight, whose very interesting writings most of you have read from time to time, but as the advocate of the "Membrane Method," his papers are exclusivly devoted to an exposition of this one system, and his term "Waterproof Engineering," applied to this method alone, is a misnomer. While the "Membrane Method," or the enclosing of a substructure in a bituminous stratum, is possesst of greatest practical efficiency, Mr. De Knight refuses to recognize in his papers that there are conditions in which the application of his pet method might be wholly impracticable from an economical standpoint. In severely condemning the use of surface coatings, or cement waterproofing compounds, he ignores the stubborn fact that a bilding already in place, which proves leaky below ground, cannot be remedied by the membraneous method. except at a comparatively exorbitant expense. So it is with the exponents of the asphaltic mastic waterproofing for universal use. when they fail to limit the use of such methods to their proper field.

It is also the same with the manufacturers of waterproof paints. who, instead of wisely limiting their recommendations for the uses of those paints to conditions where they have their chief value, recklessly undertake to exploit them for indiscriminate, and often most inapplicable purposes.

In this class also, we must include the manufacturers of cement waterproofing compounds, materials which in certain conditions are unexcelled, but which may be misapplied to the great vexation, annoyance and loss of the user.

Impartial advocates of scientific waterproofing, those not interested in any special material or its advancement, cannot fail to admit that there is a good deal of merit in many of the methods which have been successfully employed in the past. Practical common sense compels us to acknowledge that there is no sure and universal remedy for all conditions, and we realize that we must study waterproofing problems in the same broad way as that with which we study all other engineering problems, and accept only that method of treatment which is best suited to individual conditions.

As technical investigators, we should not depend upon what we read in trade literature, where we find glowing eulogiums of certain products. We must weigh the facts, and then decide for ourselves.

The mind of the engineer and architect is trained to investigate, to suit the means to the end, the remedy to the conditions. We must follow the same procedure here as we apply elsewhere. This being done, mistakes and failures in waterproofing would become increasingly rare.

I make this earnest appeal because the need of scientific waterproofing is daily on the increase, while, on the other hand, many are deterred from availing themselves of its possible benefits, because of the conflicting statements to which I have referred.

Let us now ask, how can the situation be improved?

First, by eliminating the causes above outlined.

Second, by systematic investigations undertaken by technical bodies for increasing our knowledge of the subject. A few are now in progress. The U. S. Government is now making tests at St. Louis; the American Society for Testing Materials have a waterproofing committee; the National Association of Cement Users have the subject in hand, and we trust that when their reports are ready a great deal of information will be available. I might suggest that this Society would find in such an investigation a very useful field of endeavor.

One of the principal difficulties encountered in committee work of technical societies and in testing laboratories, especially in waterproofing studies, is the tendency to rely too much on laboratory tests, particularly small scale tests. It seems to me that the examination of waterproofing systems in the field should have as much influence in determining their efficiency as the laboratory tests, and each should supplement the other. While we may be deciding the fate of a material adversely, owing to the negativ character of the tests, we may have the pleasure of seeing the same process applied on a large scale in the field with results which prove its efficiency. This has happened more than once. Conversely, what has shown up admirably in the laboratory, may, in the safer test of actual practis, prove entirely inadequate.

THE DESIGN OF WATERPROOFING SYSTEMS.

A thoro understanding of the correct designing of waterproofing systems presupposes an understanding of the laws of physics and of chemistry. The designer should be, in a measure, familiar with the physical and chemical nature of the materials he proposes to employ, and their effect upon the structures. He must be familiar with the calculation of hydrostatic pressures, so that he can guard against the making of floors and walls too thin for safety or too thick for economy. He must be familiar with the influences of subsurface and general atmospheric conditions on the materials he employs, so that asphalt will not be used where coal tar will serve the conditions better, or *vice versa*. The designer should be conversant with the whole gamut of possibilities, and his mind should be ceaselessly on the watch for causes and effects, picking out the necessities of the problem, providing for them and fitting in the details to make a complete whole.

All the methods of waterproofing in use may be classt into three general types:

1st. The bituminous shield or membrane, including all the processes in which the structure is surrounded by an external shield or membrane.

2d. The integral, in which the masonry is made impermeable *per se* or where a waterproof cement coating is employed. This is also termed a "rigid" method in contradistinction to "elastic," which distinguishes the membranous method.

3d. Superficial, including all those processes in which the waterproofing is applied to the surface of the structure.

Let us assume for a moment that we are called upon to design the waterproofing of some representativ bilding. It is customary, on the part of many architects, to merely follow the methods of applying a certain number of coats of asphalt or felt and to stop there, or to patch up specifications based on some other structural work. If we are to handle the problem rationally, we must approach it in the same way as we approach any other problems in design.

DESIGN OF SUBSTRUCTURAL WATERPROOFING.

Let us consider first the substructure of the bilding. From the necessary data obtained to determin upon the character of the foundations, we learn, more or less accurately the nature of the underlying materials. It is of the utmost importance that we take this fully into consideration, in the designing of the waterproofing system. If the ground is rocky, containing no seams, or is dry earth free from springs or subterrenean streams, the difficulties are immensely lessened, and we can procede to design a continuous external shield of bituminous materials, or an internal lining of waterproof cement mortar, as economy and other conditions may dictate. Should, however, the substrata contain water-bearing or saturated earth, we must provide for drainage during and possibly after construction, to relieve the pressure against the structure as much as possible. We must also determin the amount of hydrostatic pressure that may develop against the walls and floor.

Bituminous shields or membranes, having of themselves no great strength, must be weighed down by masonry or otherwise protected so as to prevent their displacement by the external pressure. The extent of the pressure to be resisted will also in a great measure determin the thickness of the waterproofing stratum to be employed.

The character of the ground water coming in contact with the waterproofing must also be taken into account, for if acids, sewage, gases and other foren matter are present, the materials for waterproofing should be selected with a view to their power of resistance to such influences.

Only a short time ago, one of the modern office palaces in New York, constructed in the most lavish style, with unlimited means, suffered from a neglected precaution of this kind. Situated not far from the shore, with its sub-basement 14 ft. below the tide level, almost every precaution was taken to obtain a substructure that would be absolutely dry. No expense was spared, and with just pride the contractor pointed to the work as one of the greatest waterproofing achievements of the age. In the sub-basement of this bilding was installed expensiv machinery to heat and light the bilding and provide power for the elevators. Before the lapse of many months, however, it was found that water had begun to come

USE OF DIAGRAM.

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ows that rods placed in both directions,
s apart, do much to bond the cellar floor,
nings from settlements, etc. These rods
or ⅝-inch, and add about 1 to 1¼ cents per
e cost.
reinforced slabs is, however, not generally
the intention of this diagram is to afford a
al method by which such slabs may be
table is derived from experience and em-
which closely follow the advanced theory
concrete is a 1 : 3 : 5 mixture and the steel
s medium, the most widely used steel of

gives the weights of slabs, their cost per
percentages of reinforcement required for
from 0 to 18 feet for all spans from 5 to 28
cknesses of slabs from 4 to 15 inches. The
of unreinforced concrete slabs are also

vay to explain the use of the table is to take
ple.
ad of 10 feet of water and a span of 15 feet
ar walls. The lifting pressure on the floor
r 625 pounds. Deducting the approximate
ab (taking it at one-sixth of the load, or 104
625—104, equals 521.
me left of the table, under "water pres-
and, moving horizontally to the right, note
a plain concrete slab, with no reinforce-
t about 98¼ cents. Continuing on the same
ach the diagonal straight line for spans
d thence running vertically up (or down,
be), we find that the 12-inch slab would cost
, and the 11-inch slab about 88.8 cents, and
about 89.1 cents. Choose the 11-inch as the

n at 625 pounds, deduct the correct weight
given at the bottom of the table, which is
s gives 497 pounds. Again starting at the
w pressure, move to the right horizontally
agonal, and we find that 12-inch slab costs
the 11-inch slab 87.4 cents, and the 10-inch
This shows that the 11-inch slab is the one

int of intersection found with the 11-inch
horizontally to the extreme right and read
"section of steel in one foot of slab is .84." It is then only necessary to use this section in any rod available.

It will sometimes happen that the first trial will not give the exact slab, but the second will.

The price of concrete has been taken at 30 cents a cubic foot, in place; and of steel 3 cents per pound, in place; which is rather higher than the average. The table, however, is close enough to allow for all variation, as these prices will not affect the ratio sufficiently to change the slab. The designer can overcome any changes by giving either the thin or thick slab the preference, according to the relativ prices of concrete and steel.

Quarter-inch rods should be placed 12 or 18 inches apart, at right angles to the reinforcing rod. The reinforcing rods should be laid with the upper edge 1 inch from the top to the centre at the middle, and should curve easily to about 2 inches from the bottom at the abutments.

The reader should bear in mind that sufficient pressure must exist at the abutments to hold the slab down. This is generally safe, but should be examined for all large spans or deep heads of water.

The waterproofing can be applied as usual by first laying 3 inches of concrete and then the waterproofing material, and above that the concrete slab as obtained from the table. The use of waterproofing compounds that are mixt directly in the concrete are good, but when these are used a thin slab with a high percentage of reinforcement should be used, and then 2 inches added for safety.

The reason for the high percentage of reinforcement is to obtain the advantage of elasticity in the waterproofing in order to resist settlement, shrinkage, etc. If this is borne in mind, the compound is perfectly satisfactory and should prove more economical.

In cases where the cellar is less than twice as long as wide the table can be used by taking each span, and using half the section given, omitting the ¼ or ⅝-inch rods mentioned before, as the rods now run in both directions. The upper row of rods should be the shorter and placed 1 inch from the top of the slabs.

In picking out the rods always use a section larger than called for, and in case of reinforcing both ways this should be particularly adhered to for the long span.

The slab should be carried right thru under the walls and the waterproofing continued on the outside, unless a waterproof compound be used on the inside, as is frequently done.

in at various points along the walls and floor, and the conditions soon became so annoying as well as damaging that investigation had to be made, with a view to correcting the trouble. It was thought at first that the enormous weight of the colums had punctured the waterproofing, thus causing the leaks, and while this was a probable theory, further examination disclosed the fact that on the plastering, along one section of the wall, there appeared great black blotches of dampness, which were overrun with vermin. We have never known that a clean concrete wall supported animal life, and some animal or vegetable material must have been present upon which they could germinate and feed. Not far from the bilding was a large sewer outlet, and adjoining the foundation were the street sewers, thru the linings of which the sewage no dout readily filtered.

The material used in treating this foundation was possibly being attackt by the constituents of the sewage, under which it seemed to have broken down, and the difficulty was remedied by the application of an interior cement mortar plaster at a great expense. The mistake of having failed to take all the conditions into account in making the plans for the structure in question was the cause of the trouble. The same materials used here have given entirely satisfactory results in other localities, but they were not proof against this action. The action of sewage on bituminous materials is as yet a very unsettled question. When this case came to my attention, I addrest letters to the leading authorities on the subject, but no actual tests along this line had been made, and the answers were very indefinit. I am in hopes, however, that the near future will reveal some interesting facts in this direction, as I am preparing to undertake some tests on bituminous materials, by suspending them in sewer manholes. This subject will become of increasing importance as the waterproofing of sewers comes into general use.

I bring these facts to your attention to indicate how careful the designer must be, to foresee and forestall any possible injury to his waterproofing. Possible effects of frost or illuminating gases, of settlement or vibration, and other parallel conditions, must be considered with a view of using the right material in the right place. In many instances various materials or methods may be employed with equally good results, and then, of course, economical considerations are the controlling features. It is for the engineer or architect to decide what shall be used, and it is to them that the owner looks for results. We must not try to evade our responsibility by shifting the blame to the contractor or the manufacturer.

Design of Superstructural Waterproofing.

Let us now consider the superstructure of the bilding. How shall we dampproof it? We must continue our investigations along similar lines. Shall we use the method of furring and lathing, or clay tile, or metal lath, or wood? Or shall we apply the plaster directly to the wall? Shall we waterproof from the exterior, or on the interior surface? If the bilding is of brick, it can safely be waterprooft on the interior without fear of trouble providing the work is properly done. If the bilding is of concrete we are not so sure of the adhesion of the plaster to the waterproofing film, as experience in this line has been too varied to allow us at this stage to speak decisivly. The smoothness of the concrete surface militates somewhat against this method, since there seems no key for the bonding of the plaster, which is not the case in the large joint area of a brick or stone wall. In case of concrete bilding walls, the dampproofing may be done; first, by hacking the concrete, or pitting or rough-finishing the surface, and applying an interior coat; second, by waterproofing from the outside; third, by the "Integral" method, the addition of a compound to the cement, in which case the waterproofing compound becomes an integral part of the mass; fourth, by furring and lathing to provide a necessary air-space. The second named method is efficient, but the material being on the exposed surfaces requires, of course, periodic renewal, and while it is practically the best method of dampproofing in existing structures, it is not as permanent as interior dampproofing properly done. The third method will be referred to later. The fourth method is so old as to require no comment.

Necessity for Inspection of Waterproofing.

Let us now consider that plans and specifications are completed and we are prepared to begin work. Do we look after our waterproofing as we do after other details? Usually not. How many

PLATE 79.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LEWIS ON WATERPROOFING—
AN ENGINEERING PROBLEM.

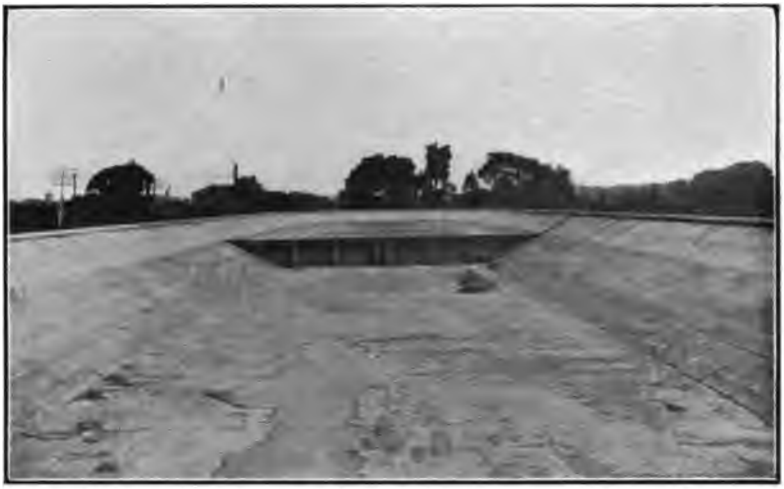

Fig. 1.—Reservoir at Mansfield, Ohio. Asphalt Waterproofing Laid on Concrete Base, Covered with Concrete Lining Laid in 10 ft. Square Sections. Expansion Joints ½ in., Filled with Asphalt Compound.

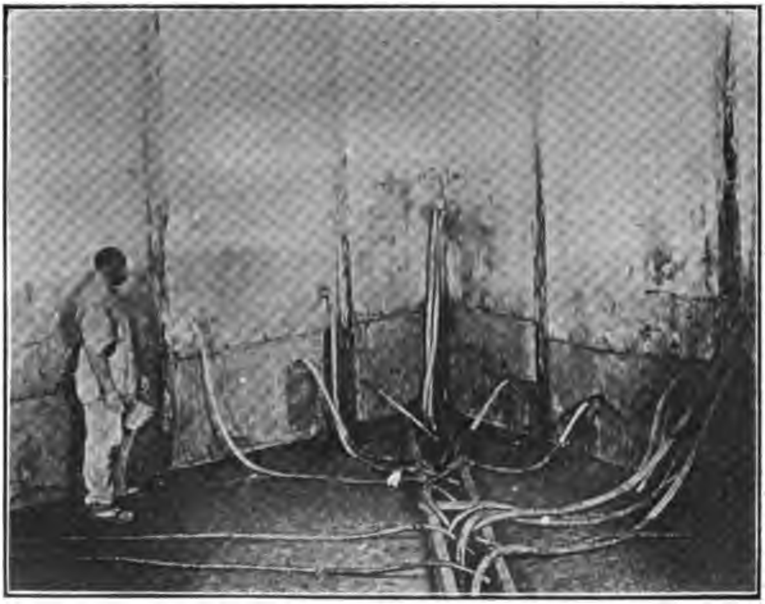

Fig 2.—Bleeding Walls, During Application of Cement Coating. Iron Pipes with Toothed Cutting Edges Driven Into Wall, and Connected with Hose Leading to Sump. Coating is Placed on Dried Wall, and when Set the Holes are Plugged with Pine Plugs and Covered Over.

inspectors can tell whether the walls are in proper condition to receive the waterproofing? How many can tell whether the waterproofing materials specified have been supplied, or these substituted by a cheaper material? All tars, asphalts and black paints look alike and to many are one and the same thing, and for lack of competent inspection, the best laid plans may be brought to naught.

Why is it that bad conditions are often discovered in bildings where the plans and specifications have been all that they should be? Because the work is improperly done—the material defectiv, good work not properly protected, or even injured, or conditions unsuited to the work. After the bilding is in place and leaks are discovered, the architect puts the responsibility on the contractor, he on the architect's inspector; there is a general shifting of responsibility. The result is a loss to all concerned, in money and in reputation.

Before we allow cement to go into the work we generally test it ourselves or have it sent to the laboratory for testing. We examin our brick or stone to see that they are up to our standard. We often go to unnecessary refinement in examining our sand and stone for concrete, but how often do we take the trouble to find out whether we are getting the waterproofing for which we are paying? Why should we not test these materials as they come on the work, in the same way as we test our other construction materials? Why pay for asphalts when we are getting oil substitutes? Why accept soap or powdered lime when we are buying waterproofing compounds?

So many failures have been reported from the application of waterproofing when the walls were too wet, or too rough, and from the failure to protect the waterproofing from injury due to unnecessary exposure, back-filling or other causes, that a competent inspector should be always on the work, and no work done in his absence.

Defectiv waterproofing is almost worse than no waterproofing. It is costly to repair; especially when on the exterior of the foundation walls, the origin and source of the trouble can with difficulty be traced. It follows, therefore, that the best is the cheapest. It costs ten times as much to repair a bad job as to do it right in the first place. All of which goes to show that it behooves us when asking for bids not to look with favor upon those figures which are ridiculously low. This has often proved a disastrous policy when unforeseen difficulties are encountered, which is a common occurrence in subsurface work. All the more reason why we should have proper and adequate inspection. Responsibility of the bidder in contract work is just as important as the amount of the bid.

SUMMARY OF REQUIREMENTS FOR SUCCESSFUL WORK.

1. Careful Investigation.
2. Adequate Design.
3. Suitable Materials.
4. Careful Construction.
5. Favorable Conditions.
6. Intelligent Inspection.
7. Systematic Tests of Material.
8. Responsibility of Contractor.

With all these given careful attention, the waterproofing of structures becomes as certain and permanent as we can possibly expect it to be.

With this general survey of waterproofing as an engineering problem let us proceed to a consideration of some of the more intimate details of the question. Our structures are exposed to trying conditions, with which the engineer is, as a rule, very familiar, altho the connection between these conditions and the desirability of waterproofing is often lost sight of. These conditions include action of atmospheric agencies, such as wind, expansion, contraction, absorbtion, chemical action, etc.

CAPILLARY ATTRACTION AND REPULSION.

Bilding materials are, as a rule quite porous, and ordinary mortar in which our masonry is laid is very highly so. The variations in porosity are so great that no table can be taken as conclusiv. Just at the present time the engineering profession is paying a great deal of attention to the porosity of concrete, and the technical papers are full of articles on impervious concrete. Those who have workt in the laboratories claim that concrete can be made impervious without special treatment. Practical concrete workers, on the other hand have found this to be a difficult matter, even when the utmost care is exercised in mixing and laying. There is no dout that concrete can be mixt in the field so that a nearly impervious mass can be obtained, but it is questionable whether the extra trouble and amount of cement required to do this does not in many cases make the process less desirable than applying a suitable waterproofing treatment.

Furthermore, we must draw a distinction between an impervious concrete and a non-absorbent concrete. A concrete may be practically impervious to water under pressure, and yet, thru the slow but persistent action of capillarity, dampness may penetrate it many feet. This distinction is singularly overlookt by even leading writers and practitioners, and yet it is an all-important detail in the concrete block bilding, and possibly in the reinforced concrete bilding superstructure. I say possibly, because for this class of work imperviousness is not enough. The corrosion of steel in concrete is still an open question. We should have non-absorbency, water-shedding or anti-hydrous concrete, or as it is appropriately called "capillary negativ," in contradistinction to ordinary concrete which absorbs water, and is, therefore, "capillary positiv."

The subject of capillarity is very little understood by the ordinary worker in concrete, and its power is not comprehended. Let us for a moment go back to our physics.

The action of capillarity is best explained by referring to the action of the liquid in fine tubes. Liquids, when brought in contact with solids are either repelled or attracted. Those liquids which are attracted to the material in the tube rise, while the others are deprest. The amount of rise or depression depends upon the diameter of the tube and the character of the liquids. The finer the tube, the greater the capillary attraction. Thus, in a converging tube, water is drawn to the narrow end, while a capillary negativ material is drawn to the wide end. Cracks in masonry walls may be considered as a succession of such tubes converging into the interior to which the water is drawn.

If thru the addition of a waterproofing compound to the concrete work, or the impregnation of the masonry surfaces with anhydrous or capillary negativ materials, we destroy the absorptiv power of the wall, then we may rest secure as to the dryness of the structures, provided, of course, that the material is stable in character and that it has been properly applied.

The architect and engineer realize, as a rule, the important part that temperature changes play in the durability of structures, but it is difficult to impress upon the lay mind that the distortion due to this cause, or the expansion or shrinkage resulting from temperature changes is of much consequence. In order to bring out these facts Table 1 has been prepared, giving the changes in dimensions for a change of temperature of 100° fahr., which is common in our climate. As the volume increases with the cube of the length we notice that the volumetric changes appear very large. Thus, in the case of plaster there is an increase of 2.7 cu. ft. in a 10-ft. cube. When we realize that in order to produce these changes enormous mechanical power must be applied, we can understand the strain induced in the structure when, owing to rigidity, it is not free to move. Of course such masses are obtained only in dams and similar structures, and the results are evidenced by cracks.

TABLE 1.—VARIATION IN DIMENSIONS OF HOMOGENEOUS BODIES FOR CHANGE IN TEMPERATURE OF 100° FAHR.

Material.	Change in length per 100 ft.	Change in area of 10 ft. by 10 surface.	Change in volume of 10 ft. by 10 ft. by 10 ft. cube.
Brick....................	0.08 ft. = ⅜ in.	0.06 sq. ft.	0.09 cu. ft.
Concrete..................	0.06 " = ¾ "	0.16 "	0.40 "
Cement (neat).............	0.06 " = ¾ "	0.12 "	1.80 "
Granit....................	0.04 " = ½ "	0.08 "	1.20 "
Masonry (misc)............	⅜ in. to 1 "	0.06 to 0.16 sq. ft	0.90 to 2.40 cu. ft.
Brick mas'y...............	0.02 ft. = ¼ "	0.04 sq. ft.	0.60 cu. ft.
Plaster...................	0.09 " = 1⅛ "	0.10 "	2.70 "
Steel.....................	0.06 " = ¾ "	0.12 "	1.80 "
Iron......................	0.06 " = ¾ "	0.12 "	1.80 "
Sandstone,................	0.04 " = ½ "	0.08 "	1.20 "
Pine wood.................	0.03 " = ⅜ "	0.06 "	0.90 "

MECHANICAL EFFECTS.

10-in. bar changing $\frac{1}{20}$-in for 80° Fahr, equivalent to 50 tons.
1-lb. iron changing $\frac{1}{285}$ for 180° Fahr .. ..16 000 ft. lbs. load.
Freezing water....................................10 tons per sq. in.
78 in. concrete bar 1: 8 : 6 in shrinking gives Compression 65 000 lbs. per sq. in.
20 000 lbs.-80 000 lbs. per sq. in. produced by shrinkage.

The injurious effect of temperature changes is aggravated by the power of absorption inherent to bilding materials. Absorption followed by frost and thawing results in the opening of cracks,

PLATE 80.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
LEWIS ON WATERPROOFING—
AN ENGINEERING PROBLEM.

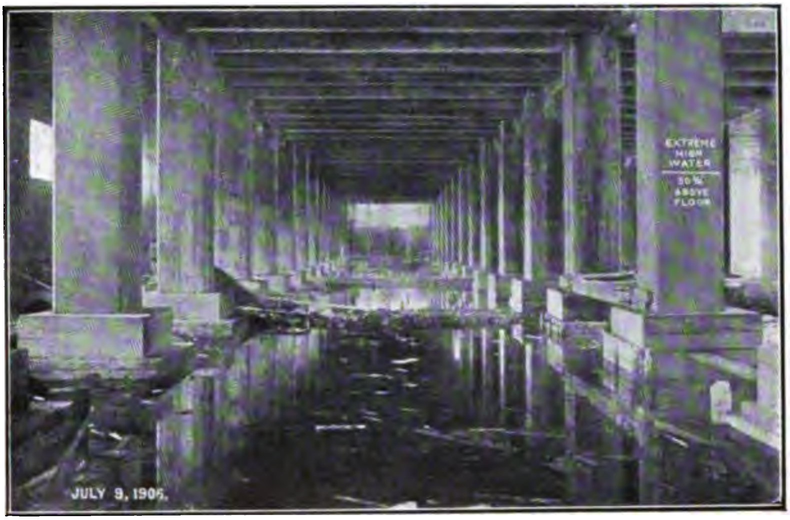

FIG. 1.—S. S. MCCLURE COMPANY BILDING, LONG ILAND CITY, BEFORE BEING WATERPROOFT. FOTOGRAF TAKEN 48 HOURS AFTER PUMPING BEGAN. WATER IN TEST PIT SHOWED 54 IN. ABOVE FLOOR.

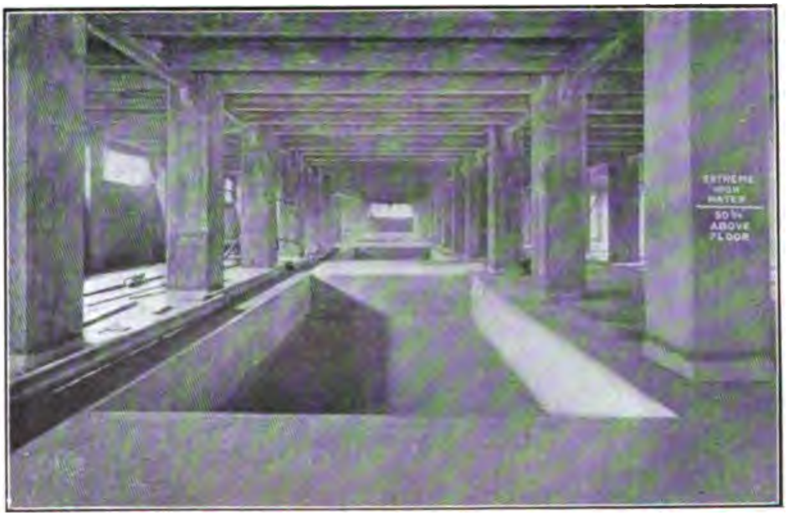

FIG. 2.—SAME BILDING AS IN FIG. 1. WATERPROOFT BY THE "INTEGRAL" METHOD, GAINING 4 056 CU. FT. OF SPACE OVER DESIGN WITH "MEMBRANOUS" METHOD.

spawling of stone, and rendering the structure still more susceptible to the action of the elements. It is to prevent this that exterior coatings have their chief value.

TABLE 2.—ABSORPTIV POWER OF BILDING MATERIALS.

Common Brick	2 to 25%
Hard burnt brick	.08 " 8%
Marble	2 " 5%
Lime Mortar	50 " 60%
Cement Mortar	10 " 20%
Concrete, ordinary	5 " 25%
Concrete, treated	traces " 5%
Timber	16 " 9%

PRACTICAL DETAILS OF CONSTRUCTION. MEMBRANE METHOD.

The design for waterproofing a substructure by the shield or membrane method involves the bilding of a retaining or supporting wall for supporting and protecting the waterproofing from injury during and after erection. Excellent results have been obtained in numerous structures. It is the best method to employ where there is danger of much settlement, as in the case of unreinforced walls. An adequate drainage system should be included and an emergency sump as well. Drainage is more certain, and in the end more economical than ballast. When no pressure exists and dampness only is to be resisted 2 or 3 coats of a heavy asphalt or coal tar compound applied cold, reinforced by one layer of felt or burlap will answer. For wet walls hot material must be used. Plate 77, Fig. 1, shows the section of the substructure of a bilding waterprooft by this method.

TABLE No. 3.—THICKNESS OF WATERPROOFING REQUIRED FOR VARIOUS HEADS OF WATER.

Head in Feet.	Coal Tar and Felt.	Commercial Asphalt and Felt.	Special Felts and Compounds.	Asphalt Mastic.	W. P. Cement Mortar.
0	2 ply.	2 ply.	1 ply.	¼ in.	½ in,
1	3 "	3 "	2 "	½ "	⅝ "
2	4 "	4 "	3 "	½ "	⅝ "
6	5 "	5 "	4 "	½ "	⅝ "
8	6 "	6 "	5 "	½ "	¾ "
10	7 "	7 "	6 "	½ "	¾ "
15	8 "	8 "	7 "	¾ "	¾ "
20	9 "	9 "	8 "	¾ "	¾ "

Plate 78 shows a diagram for proportioning reinforced concrete floors of substructures for various heads of water, for various spans, also giving cost for various size slabs, both reinforced and unreinforced. In proportioning the foundations of bildings it adds to the life of the waterproofing to minimize as much as possible, disturbance thru settlement. This can be done by proper reinforcement, and great economy in material results as well. With a large head of water on the foundation, an unreinforced concrete floor must be very heavy to counteract the pressure, but by properly reinforcing the cellar floor to the walls and colums, the entire weight of the superstructure can be brought into play in resisting the water-pressure, and the thickness of the floor may be greatly reduced.

In using bituminous waterproofing, one of the important considerations is to have a good surface upon which to apply it. If this is too rough or ragged, a good hold cannot be obtained and air pockets are formed which eventually fill up with water.

The surface should also be clean and dry. It is a difficult thing to place the material on a wall reeking with water, and proper drainage should be maintained. If this is not done, the material is liable to be prest off the wall before the supporting masonry is placed.

Every detail of the work requires careful attention and unless conscientious workers are employed, materials may be wasted and be of no benefit. The mopping of the materials should be done quickly, uniformly, and thoroly, and while it is at the proper temperature. The joints in the felt should be well broken and cemented together. Good work cannot be done in very cold weather, as the cold air chills the bitumen too quickly.

It is of utmost importance also that there be not at any point. a break in the continuity of the work. Disregard of this essential has been the cause of many failures. One of the difficulties in securing continuity is encountered in the joining of new work to old. The laps become covered with dirt, cement mortar, water, etc. Before any new work is added, the joints should be thoroly cleaned and coated with the cementing material. It is here that a good inspector is needed, as workmen are often tempted to neglect this precaution.

A bad case of waterproofing came to my notice in a large bank bilding on Long Iland, where the interior was dampproof and plaster applied without furring. The continuity of the waterproofing was broken at the floor lines; moisture found its way thru the breaks and entirely ruined the decorations.

The application of the fabric and the cement does not by any means complete the work. The placing of the masonry against the waterproofing must receive careful attention on the part of the inspector. Innumerable good jobs have been injured and even ruined by being punctured during this operation, especially when the backing is concrete. Sharp projecting stones coming in contact with a film, will break a hole thru the latter which will admit water, and the source of this leak will be extremely difficult to discover. It is always advisable, where backfilling or concrete comes in immediate contact with the waterproofing, to protect the latter with a 1-in. coat of cement mortar.

It frequently happens that other work, such as plumbing, must be installed after the waterproofing has been set in place, and not infrequently the plumbers, or other workmen, who have but little conception of the importance of preserving the waterproofing intact, make incisions in the film for the insertion of pipes thru walls, and neglect to make the proper repairs to such breaks. Of course, the consequence of this recklessness is that leaks appear, with a division of responsibility among the various contractors. The specifications should clearly provide against any tampering with the waterproofing without the direct knowledge of the architect or others in authority.

Plate 79, Fig. 1, shows a reservoir lined with concrete in sections over a bituminous film, the joints being filled with asphalt. Reservoirs may be waterprooft in substantially the same way as walls, the principal difference being that the coating is placed near the water surface. The large area exposed to temperature changes, particularly during construction, makes it advisable to lay the lining in sections as shown, filling the joints with a bituminous cementing material. While the bituminous stratum should be anchored to the under layer of concrete or brick, it should not be so rigidly attacht that disturbance of either the under or the covering layer will break it.

One of the most trying conditions to be encountered is the treatment of bridge floors, as the vibration due to live loads tends to break up the waterproofing. No rigid system will answer and great elasticity must be lookt for. This has been successfully accomplisht in several ways. Plate 81, Fig. 1, shows waterproofing for a concrete bridge floor on the New York, New Haven and Hartford Railroad. An elastic membrane composed of asphalt mastic or bituminous concrete, in combination with several layers of felt cemented together, and protected by a coating of cement mortar will give the best results.

In the separate system of sewage where the effluent has to be treated, we can readily see what a great saving in maintenance charges may be effected by keeping the ground water out of the sewers. This can be accomplisht at comparativly small cost during construction.

The following figures, compiled by Mr. Hammond, show the amount of ground water leaking into the sewers in various cities, due to the porosity of the sewer lining:

New Orleans, La.	1 250 000 gals. per sq. mile.
Columbus, O.	100 to 300% of dry weather flow.
Kalamazoo, Mich.	20% of capacity.
Norfolk, Va.	60% of pumping.
Canton, O.	70 000 gals. per mile.
Brockton, Mass.	2 500 gals. per mile.
East Orange, N. J.	110% of dry weather flow.

INTEGRAL METHOD.

Concrete impermeable *"per se"* may be had, of course, by theoretically proportioning the ingredients to eliminate the voids. For many conditions this is all that is required, but as outlined before, it is difficult to obtain in practis, and in many cases it is advisable to add water repellants and finely divided materials to obtain waterproofness.

Treating the concrete *"en masse"* by the incorporation of a waterproofing compound I have called for convenience the "Integral Method," as the compound is supposed to become an integral part of the structure. In this method the compounds usually employed are as follows:

PLATE 81.
THE MUNICIPAL ENGINEERS
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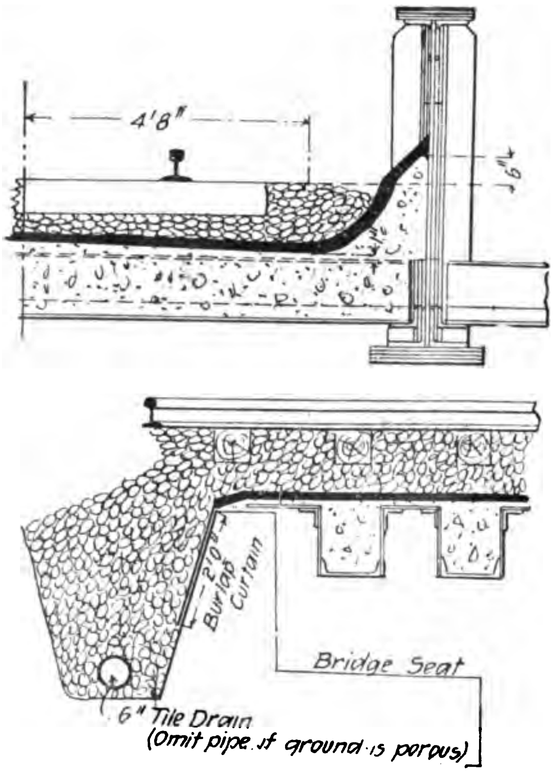

FIG. 1.—WATERPROOFING CONCRETE BRIDGE FLOOR, N. Y., N. H. & H. R. R.

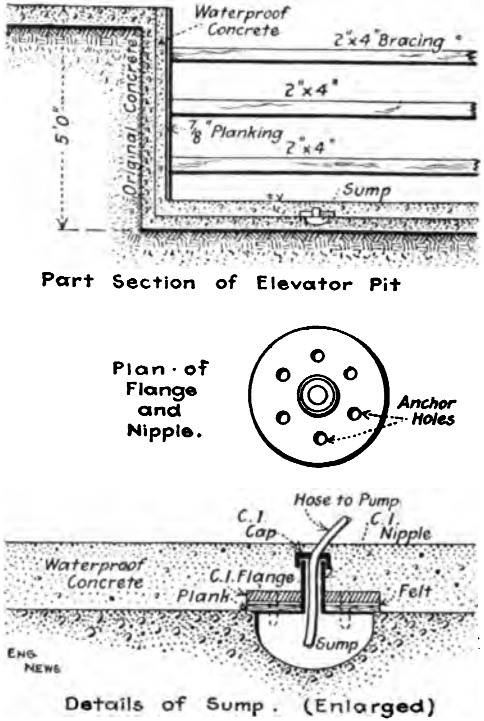

FIG. 2.—METHOD OF WATERPROOFING LEAKY ELEVATOR PITS AT SIEGEL FACTORY. S. I. 4-IN. OLD CONCRETE CUT OUT; OLD SURFACE ROUGHENED AND TREATED WITH MURIATIC ACID SOLUTION; WATERPROOF MORTAR APPLIED. HYDRAULIC COMPOUND INCORPORATED.

1st. Liquids to be added to the water used in tempering the cement. These are usually some form of chloride of lime, sulfates of aluminum or oil emulsions.

2d. Sylvester soap and alum mixtures. Powdered alum is added to the cement and soap solution to the water.

3d. Such materials as hydrated lime and metallic stearates, which are usually chloride of lime in combination with stearic acid.

The liquid compounds impart waterproofness by the formation of a gelatinous coating about the cement particles. The soap and alum mixture deposits aluminum silicates in the voids. The hydrated lime acts as a void-filler. The metallic stearates also act as void-fillers, but they also possess in a markt degree the repelling action to water before referred to. Each one of these materials possesses some good qualities, all of them reducing largely the permeability of the concrete. For lack of long time tests a definit statement as to whether their waterproofing properties are permanent, cannot be made. Some of the stearic compounds have been used in bildings that are now five years old, and as yet there is no symptom shown of a diminution in their water-repelling property. The integral method of waterproofing is particularly useful is the superstructures of bildings, and to the remedying of damp conditions in substructures already erected.

Or all the dry compounds recommended, those which seem to be most in favor with the consumers at the present time are the metallic stearates. This is because they possess not only the void-filling property of hydrated lime, but also destroy the water-absorbing quality of the treated concrete as before stated.

When first introduced it was feared that they would seriously injure the strength of the concrete, but experience has proved that this apprehension was groundless.

The results in Table 4 show the effect of the compound on the cement. They are not of sufficient duration to justify conclusiv opinions. The tensile tests were made in the usual way. The adhesion test was made by filling half a briquette mold, allowing it to set hard, then filling the remaining half. The conclusions to be drawn are:

1. The set is somewhat retarded by the use of the compound.
2. The compound decreases the strength of neat cement.

3. The compound increases the strength of cement mortar.

4. The adhesiv power of old to new work is increast by the use of the compound.

TABLE 4.—Tests of Treated and Untreated Cement.

(By Prof. Black.)

	Ordinary Portland,	Portland, with 2% Hydratite.
	Tensile strength, lbs. per sq. in.	
Neat, 7 days	740 882 854 900	600 640 655 674 } decrease.
1 cement, 2 sand, 7 days	400 438 452 464	460 464 478 500 } increase.
1 : 2—21 days	495	602 increase.
	Adhesion between new and old concrete.	
1 : 2—7 days	125 137 130 168	150 168 172 178 } increase.
	Holding-power to brick.	
1 : 2—7 days	550 610 795 865	395 440 620 820 } decrease.
	Activity by Gillmor Needle.	
Initial set	5 hrs. 40 min.	6 hrs.
Final set	8 hrs.	8 hrs. 45 min.

Professor Black was not aware of the indentity of the materials, as they were merely labeled "No. 1, No. 2," etc.

Thru the curtesy of one of the leading manufacturers I have obtained a series of long-time tests, made by the Spackman Engineering Company. Five materials are included in this test, which was of six months' duration. All were made on a 1: 5 mortar, none shows a material decrease in strength. The laboratory received the samples as "Nos. 1, 2, 3, 4, 5," without any other identifying mark. The results are shown in the following table:

TABLE 5. — TESTS SHOWING EFFECT OF WATERPROOFING COMPOUNDS ON CEMENT MORTAR, MADE BY SPACKMAN ENGINEERING CO., PHILADELPHIA, PA.

Portland cement mortar, 2% W. P. compound.	Tension, Lbs. per Sq. In.				Compression, Lbs. per Sq. In.				Permeability, C. C. Passing in 2 Hours.			
	7 days.	28 ds.	90	6 mos.	7 days.	28	90	6 mos.	7 days.	28	90	6 mos.
Compound No. 1—Aquarex, Knickerbocker Chem. Co...	360	498	....	542	1 580	2 399	....	4 498	5.5	0	....	0
Compound No. 2—Maumee, Maumee Chem. Co..........	340	475	....	575	1 284	2 299	....	4 236	10.5	0	....	0
Compound No. 3—Medusa, Sandusky Portland Cem. Co.	347	477	....	571	1 295	2 557	....	3 272	5.0	0	....	0
Compound No. 4—Hydratite, A. C. Horn Co............ ...	342	476	....	591	1 616	2 549	....	3 648	0.0	0	....	0
Portland Cement Mortar, No W. P. Compound........	342	489	....	600	1 632	2 598	....	4 841	11.5	0	....	0

A great deal of important work has been done by using a cement waterproofing compound, and some of the largest bildings in the city have been treated in this way. The City Investing Bilding and the Hudson Terminal Bilding furnish the highest example of this type of waterproofing. A section of bilding showing the application of the integral method of waterproofing is given on Plate 77, Fig. 2.

The plan usually followed is to apply to the inner surface of the substructural walls a continuous coat, $\frac{5}{8}$ in. thick, of waterprooft cement mortar plaster, and the same plaster 1 to 2 in. on the floor. To obtain a good result the greatest care must be exercised in procuring a rich and uniform plaster, a perfect bond of the plaster to the wall and the fundamental principle of complete continuity must be rigidly enforced, as well as careful protection while the material is setting. All this requires assiduous, painstaking work. When properly done, however, it repays the care exercised, and one of its advantages is that it is always in view and can be readily repaired. It also forms in itself a finish for the wall and floor surfaces. It obviates the necessity of excavating, and of supporting walls, which are indispensable in the bituminous method. An adequate drainage system including an emergency sump should always be provided for in the design.

One of the difficult problems to be encountered in this work is the bonding of old to new concrete. This can be effected by scratching and hacking the old surface to remove the skin or glaze, and by the application of a solution of muriatic acid in water, which should be followed by a thoro washing with water to remove the acid. No work should be placed on the walls thus treated until a competent inspector has past on its condition. (See Plate 82, Fig. 1.)

When the surface has been properly prepared, the adhesion is so strong that the plaster can only with the greatest difficulty be separated from the wall. Complete directions for doing this work will be found in the appendix.

If there is a water pressure behind the wall, and it is leaking badly, recourse must be had to temporary drainage or "bleeding," as shown on Plate 79, Fig. 2.

Plate 82, Fig. 2, shows the Baronne Bilding, New Orleans, La., waterprooft with a treated mortar. Until the advent of modern waterproofing and improved sewerage, cellars were thought impossible in that city.

TABLE 6.—Covering Capacity and Cost of the above listed Compounds.

The average conditions require that the quantity of waterproofing compound should equal 2% of the Portland cement, or 8 lbs. of compound to each bbl. of the cement. At the rate of 12 cts. per lb. the cost, therefore, of waterproofing one bbl. of Portland cement with compound would be 96 cents.

The area which one bbl. of Portland cement in various mixes will cover, and also the cost of the compound only per 100 sq. ft. of coating, are set forth in the following table:

Proportions.	Thickness of Coating.	Yield per Bbl. of Cement, Sq. Ft.	Cost of Compound per 100 Sq. Ft.
1 Cement 1 Sand	1 in.	67	$1.43
	¾ in.	90	1.08
	½ in.	134	.72
	¼ in.	268	.36
1 Cement 2 Sand	1 in.	104	.93
	¾ in.	139	.69
	½ in.	208	.46
	¼ in.	416	.23
1 Cement 3 Sand	1 in.	140	.61
	¾ in.	187	.45
	½ in.	280	.30
	¼ in.	560	.15

PLATE 82.
THE MUNICIPAL ENGINEERS
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LEWIS ON WATERPROOFING—
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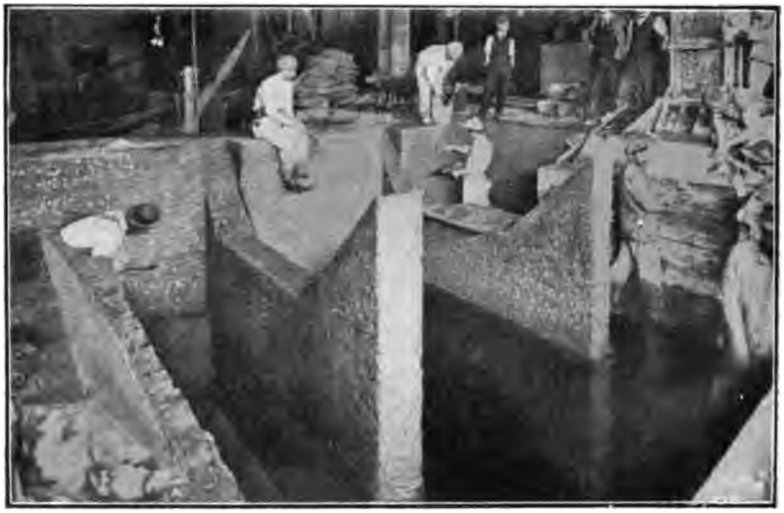


FIG. 1.—CITY INVESTING BILDING. PREPARING THE WALLS AND PLACING WATERPROOF CEMENT COATING IN GENERATOR FOUNDATION.

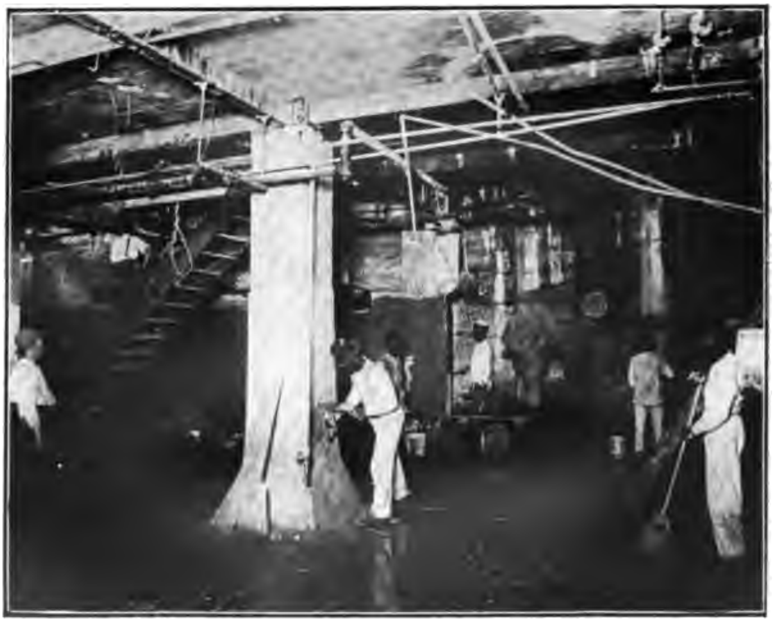


FIG. 2.—APPLYING CEMENT COATING ON INTERIOR OF BARONNE BLDG., NEW ORLEANS, LA.

SURFACE COATINGS.

Waterproof surface coatings were used on bildings in ancient Rome and Greece. Some of the stones in the English Parliament bildings were saved from decay by surface treatment. One of the most notable examples in this country is the Obelisk in Central Park, which was treated with paraffine applied under heat. This was twenty years ago and the material is still doing its work of keeping out the water. Had it not been treated it would have been seriously injured by this time, as it could not stand the rigor of the northern climate. This work is described in detail by Eggelstone in *Transactions,* for 1886, Am. Soc. C. E.

Surface coatings have their greatest value in superstructural work. They have also been extensivly used in reservoirs, bathing tanks, etc.

Probably the most permanent of the surface coating methods is the injection of hot paraffine into the pores of the surface as already referred to, driving the material in quite deeply. The paraffine should be specially hardened to resist the sun's action. Being insoluble in acid or alkalis, and practically immune from atmospheric action, a very durable job results, and the twenty years during which the Obelisk has been stubbornly resisting the attacks of the elements bear witness to its efficiency. This method is equally applicable to stone, brick or concrete. It is quite an expensiv process, but the result justifies the expenditure.

Another method of infusing the surface pores with paraffine is to prepare a super-saturated solution of the material specially hardened to resist the sun's action, in a volatil carrier. This is applied with a stiff brush, the material being well rubbed into the pores. At least two, and, preferably three, coats should be used. The carrier has great penetrating power, and upon its evaporation it leaves the paraffine in the pores. This method is much cheaper, but its life is much shorter. Work of this kind has remained tight after five years. This forms the bases of some of the commercially successful processes.

In a swimming pool at Pittsburg, Pa., before waterproofing the bath, there was leakage enough to occasion a damage suit by the owners of the adjoining property. After treatment with paraffine solution the leakage was entirely stopt. This work was done four years ago.

The Sylvester method of alum and soap is also a favorit method and one of the oldest. It requires, however, a larger number of coats, and it is just as expensiv, requires more labor and is not any more permanent than either of the others.

In this connection I may say a word on the subject of paints for concrete surfaces. The question is often askt whether an ordinary linseed oil paint will give a waterproof surface. There are two difficulties encountered in using an oil of this nature on concrete. First, linseed oil is an unstable compound, and does not have a very long life. Again, the oil coming in contact with the alkali in the cement produces a soap which is soluble in water and is soon washt off.

A curious and interesting case of this kind occurred recently at Mt. Vernon, N. Y., when, what was put forward as a special concrete paint was applied to the walls of an apartment house. Several months later, the surface began to assume an ugly yellow color, and the painting contractor was called in to investigate. He began to rub off the paint, and the brush was promptly filled with soapsuds. He first was inclined to believe that his brush or the water was not clean, and fresh water and a new brush were brought to work, only to have the same experience repeated. The more he rubbed the richer became the suds. It was not difficult to convince him that the combination of the alkali in the cement and the oil in the paint formed a soap. The entire surface had to be cleaned and a paraffine coating applied. Paints for concrete should be free from vegetable oil, and should be preceded by a waterproof coat on exposed surfaces.

Before applying dampproofing materials, it is important, just as much so as in sub-surface work, that the surface be dry and clean, and a competent inspector should oversee the conditions.

In bildings in course of construction the dampproofing may be accomplisht by the application of a bituminous film over the inner surface of all exposed walls. A number of good materials especially prepared for this purpose are to be had, and ten years of experience have demonstrated their capacity for providing a perfectly tight wall, when applied under right conditions. Not being exposed to the elements, they have a long life, and they obviate the necessity of furring and lathing, thus serving an economical purpose. They save the cost of an air space and prevent other disagreeable features which are indispensable accompaniments of the air space, such as the loss of room and the harbor afforded for vermin. They have, however, the disadvantage of not preventing efflorescence on the exterior. A large number of brick bildings have been treated in this way with satisfactory results. The film is a fairly good non-conductor, and it has some value as an insulating medium, but not as much so as the air space. Its use in concrete walls has been limited as before stated. Some large concrete bildings have, however, been recently treated by this method, and the action of the materials is being watcht with interest. Perhaps the most important bilding thus treated is the Monolith Bilding, at Thirty-fourth Street and Sixth Avenue, New York.

Remedying Damp and Leaky Structures.

Appearance of water in basements of old structures is a very common occurrence. The leakage may result in dampness only, or the entire substructure may be flooded. Remedying such conditions is usually a difficult matter where the source of leakage is external to the structure.

Data To Be Considered in Tracing Sources of Leakage.

1. Topography of site.
2. Quantity of water present.
3. Constancy of water.
4. Mode and points of entrance.
5. Level of water.
6. Appearance.

Tests.

1. Physical examination.
2. Chemical analysis.
3. Sound test.
4. Color test.
5. Shutting off water.

The source should be determined before the remedy is applied. To determin the source a number of factors must be considered, such as are here outlined. The principal thing to determin is, whether the source is defectiv plumbing in the house, backflow of sewage or tide water, or percolation thru the walls. The latter cause is the one bearing directly on our subject, as the others can be remedied with ease, the trouble being once located. Dampness may also be caused by the condensation of atmospheric moisture on cold walls.

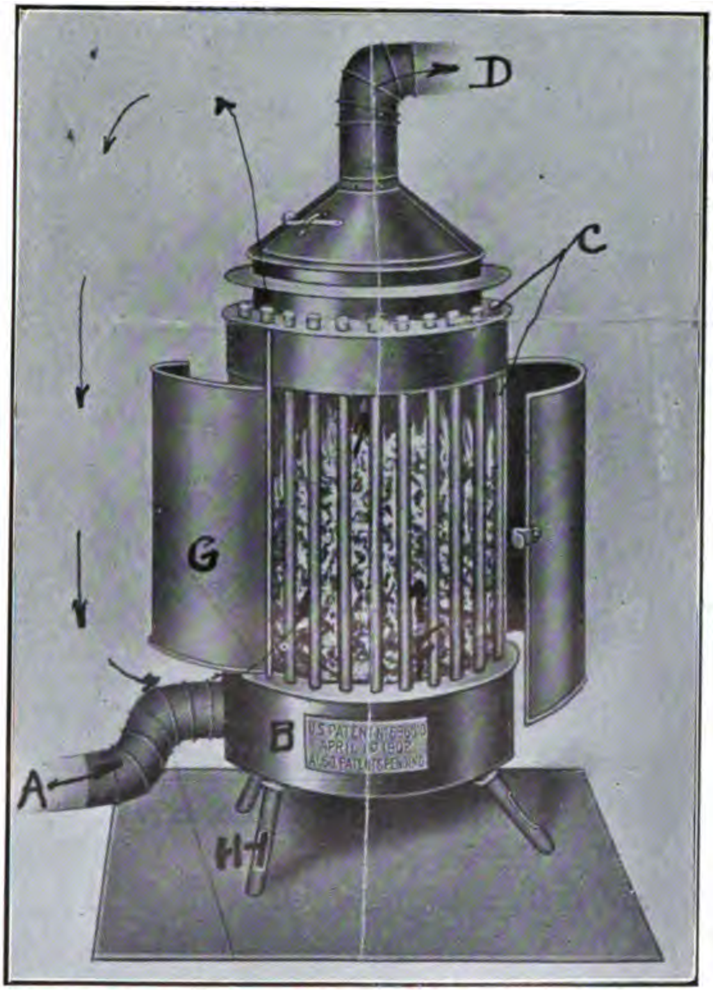
When merely dampness is to be remedied, it should be determined whether it is caused by percolation or condensation. If caused by percolation of ground water, an extra heavy coating of waterproof paint, a heavy asphaltic film covered by mortar or a waterproof cement mortar will answer, depending upon the degree of dampness.

When water is flowing, however, no interior surface coating not thoroly bonded with the wall will answer. The walls and floor should be drained and a ⅝-in. coating of waterproof mortar applied by skilled men.

Plate 81, Fig. 2, is an illustration of the Siegel Company's Bilding at Rosebank, N. J., showing method of remedying leaky elevator pits which are a source of frequent complaint.

An older but more expensiv method is to bild up on the interior a brick wall, interposing a heavy layer of bituminous waterproofing. This was practically the only method, until the application of waterproof mortars was successfully accomplisht. This is much more expensiv and very wasteful of space. Covered channel drains around the floor leading to a central sump from which the leakage can be pumpt or led into a sewer, are necessary adjuncts of the repair work. The sump may be sealed when its necessity no longer exists.

Dampness in the superstructures of houses is a common occurrence, resulting in blotched walls, ruined decorations and discomfort. Before remedying such conditions the source of the trouble should be located. When caused by defectiv plumbing or roofing, conditions can readily be remedied. When caused by leaky walls the best remedy is drying the walls and an application of waterproof coating to the exterior. New houses are particularly damp. In many European cities the government ordinances forbid the occupancy of houses until they are thoroly dried out. It would not be a bad scheme to have some such ordinance here. The walls of a new bilding may contain over 10 000 gallons of water. We have seen that bricks may absorb as much as 25% of water. The ordinary brick absorbs about ½ a pint. An apartment containing 100 000



Turk Furnace for Drying Out New Bildings.

A = Fresh air inlet.
B = Fresh air box.
C = ¾-inch pipes open at top leading from B.
D = Pipe to chimney.
F = Coke fire.
G = Doors for regulating radiator.
H = Inlet pipe for air from bottom of room. Circulation is from A into C, and finally to D, as indicated by arrows. Dries average room thoroly in 24 hours at a cost of about $3.00.

bricks will thus when saturated hold about 7 000 gallons. Wet walls are very good conductors of heat. It costs much more to heat such bildings. Plasterers are accustomed to burn stoves over night to dry the wall, but this is usually not successful, except for the interior which is sufficient for their work. In Europe a large industry has been bilt up in drying new houses and special apparatus has been devised, as shown on Plate 83.

One of the triumphs of modern waterproofing is to be found in the city of Pittsburg, for it is here, during the floods to which the city is periodically subjected, that waterproofing is put to its severest tests. During those trying intervals, when millions of dollars were lost in the great inundations a few of the more modern bildings bore eloquent testimony to the efficacy of the general design and waterproofing methods which had been employed, by the absolute immunity from damage by water, while adjoining bildings were severely injured.

In the appendix to this paper will be found a number of sets of typical specifications for waterproofing such structures as bilding foundations, pumping chambers by the bituminous and integral methods, and also railroad bridges, tunnels, etc., also the composition of some of the waterproofing compounds in use, and a short bibliography of the subject.

Before closing I want to say a word on cost. This I will only give in a general way suitable for very rough estimates. Conditions are too variable to estimate safely without previous investigations.

Cost of Waterproofing.

Hot coal-tar and felt—	
Horizontal	1st ply—$2 to $4 per square (100 sq. ft.) Additional—$1.50 to $2.50 per square.
Vertical	Add 10% to 25%
Pressure work	1 ply $4 to $5 per square.
Commercial asphalt and asphalt felt	Add 15% to 60% per ply.
Special asphalts and felts	Add 30% to 50% per ply.
Cold process—felt or burlap	Same as commercial asphalt.
Asphalt mastic 1 in	15¢ per sq. ft.

Cement waterproofing compounds—	
1 in. on floors, ½ in. to ¾ in. on walls	8 to 30¢ per sq. ft.
Dampproofing masonry walls—	
2 coats applied in place	2 to 4¢ per sq. ft.

There is a great deal more that could be said on this subject but I trust that what has been here given will, in some measure, bear out the title of this paper, "Waterproofing—An Engineering Problem," and I hope that it will be treated increasingly more so in the future by the engineering profession.

APPENDIX

TYPICAL SPECIFICATIONS FOR WATERPROOFING

RECENT SPECIFICATIONS FOR WATERPROOFING NEW YORK RAPID TRANSIT SUBWAY.

1. It is the very essence of these specifications to secure a railroad structure underground which shall be free from the percolation of ground or outside water.

2. To this end, the placing and protection of the waterproofing shall be as herein provided and as shown on the plans.

3. The protecting masonry shall be hollow terra cotta blocks, common bricks or concrete, laid as herein elsewhere provided, and shall not be less than 4 in. in thickness.

4. In places where permanent sheeting is placed at the waterproofing line, the waterproofing, if permitted by the engineer, may be applied against the sheeting.

5. All surfaces to which waterproofing is to be applied shall be made as smooth as possible; on these surfaces there shall be spread either hot melted pitch or asphaltum in a thick layer of uniform thickness; on this layer of pitch or asphaltum shall be laid a fabric of such material as may be approved by the engineer: this process shall be repeated until such number of layers as may be required by the engineer have been placed, and a final coat of pitch or asphaltum shall then be applied.

6. The term "ply," as used in these specifications shall mean a layer of treated fabric, both sides of which shall be coated with pitch or asphaltum at the time of laying.

7. The number of plys on the sides and under the floor shall in no case be less than three in ground that is quite dry; where there is a water pressure against the masonry equal to ten feet, not less than six plys. Where the water pressure is less than ten feet, such number of plys, between three and six, shall be used as the engineer may direct. The number of plys on the roof shall not be less than four.

8. In all cases over the station roofs; and also against other portions of the structure where the head of ground water is ten feet or more, two plys of waterproofing, as described above shall be used, together with one or more layers of brick laid in asphalt mastic: the number of layers of bricks, not exceeding three, shall be determined by the engineer. Said bricks, before being laid, shall be thoroly dried and warmed. At all other points where the pressure of ground water is less than ten feet, the contractor may substitute in lieu of the number of plys, as described above, one ply in hot

asphalt, and one or more courses of brick laid in asphalt mastic, as the engineer shall direct.

9. Asphalt mastic shall contain one-third pure bitumen, the other ingredients to be sand and lime dust or cement, in proportions governed by local requirements and weather conditions.

10. In those portions of the structure where the ground is dry, the regular waterproofing, excepting on the roof and for a distance of not less than four feet on the sides, may, if approved by the engineer, be omitted; in arched cut and cover work, waterproofing as called for above may be omitted, at the option of the engineer, but the extrados of the arch shall be coated with hot pitch or asphaltum of the quality described.

11. Any masonry that is found to leak at any time prior to the completion of the work and final acceptance thereof by the Board, shall be cut out and the leak stopt.

12. Pitch shall consist of either coal-tar or natural asphalt, as the engineer shall select.

13. The coal-tar pitch shall be straight-run pitch which will soften at 70° F., and melt at 100° F., being a grade in which distillate oils, distilled therefrom, shall have a specific gravity of 1.105.

14. The asphalt used shall be the best grade of Bermudez, Alcatraz or lake asphalt of equal quality, and shall comply with the following requirements:

15. The asphalt shall be a natural asphalt or a mixture of natural asphalts, containing in its refined state not less than ninety-five per cent. of natural bitumen soluble in rectified carbon bisulfide or in chloroform. The remaining ingredients shall be such as not to exert an injurious effect on the work. Not less than two-thirds of the total bitumen shall be soluble in petroleum naphtha of seventy degrees Baumé or in acetone. The asphalt shall not lose more than four per cent. of its weight when maintained for ten hours at a temperature of three hundred degrees F.

16. The fabric to be used, with the pitch or asphaltum for waterproofing, shall have been treated with pitch or asphaltum or another suitable material before being brought on the work. The fabric and the material used in its treatment shall be approved by the engineer.

17. All concrete shall be dry before waterproofing is attacht. If for any reason it is impracticable to have the concrete dry, then there shall be first laid a layer of the treated fabric, on the upper surface of which is to be spread the first layer of pitch or asphaltum; the said layer of fabric shall not be counted as of one of the required plys.

18. Each layer of pitch or asphaltum fluxt as directed by the engineer must completely and entirely cover the surface on which it is spread, without cracks or blowholes.

19. The fabric must be rolled out into the pitch or asphaltum while the latter is still hot, and prest against it so as to insure its being completely stuck over its entire surface, great care being taken that all joints are well broken, and that the ends of the rolls of the bottom layers are carried up on the inside of the layers on the sides, and those of the roof down on the outside of the layers on the sides so as to secure a full lap of at least one foot. Especial care must be taken with this detail.

20. None but competent men, especially skilled in work of this kind, shall be employed to lay the waterproofing.

21. When the finished layer of concrete is laid over or next to the waterproofing material, care must be taken not to break, tear or injure in any way the outer surface of the pitch or asphaltum.

SPECIFICATIONS FOR OBTAINING DAMP- AND WATER-PROOF BILDING SUBSTRUCTURE.

By the Use of Special Compounds—Bituminous Method.

1. *Intent:* It is the intent of these specifications to secure a substructure that will be entirely free from dampness and water penetration, and to that end, the contractor shall supply the material and perform the work in accordance with the plans and the following specifications:

1a. *Surfaces to be Waterproofed:* To waterproof the entire substructure of the bilding, the damp-course must be carried over all footings, piers and walls, over the entire cellar bottom, and on the outer face of all the foundation walls.

2. *Condition of Surface:* All walls to be waterprooft must be in a condition fit to receive the same, namely, dry, and if concrete walls, must have been allowed to set thoroly. Rough walls must be smoothed with a coat of cement mortar.

3. *Connecting Vertical with Horizontal Waterproofing:* To insure the continuity of the damp-course, the same must be allowed to lap at least 6 in. on both sides, over all footings, piers and walls, so that the horizontal and vertical waterproofing may be properly connected.

4. *Back-Filling:* After the waterproofing of the outer foundation walls has been done, it should be immediately back-filled to protect the coating from abrasion.

5. *Retaining Wall:* If, to waterproof the outer face of foundation wall necessitates additional excavation, a 4-in. retaining wall of brick (which is to be independent of the house wall) may be bilt

to receive the damp-course; should this method be employed, the house wall must be immediately bilt against the waterproofing and the back of the wall against the damp-course, well slusht in.

6. *Pits and Trenches:* Where there are pits, trenches, engine and boiler beds, they should be waterprooft, connecting the damp-course to that on the cellar floor.

7. *Water Pressure:* Wherever water-pressure is found, a sufficient resistance to this pressure must be provided in order to preserve the integrity of the damp-course.

8. *Resistance for Vertical Damp-Course:* To accomplish this, it is necessary to carry the waterproofing of outside walls, within the walls, or on the outer face of the walls to 6 in. above grade, in this manner obtaining the solid backing of the masonry to counterbalance the pressure that may be developt.

9. *Horizontal Damp-Course:* The waterproofing should be applied to the underbed of concrete on cellar bottoms, which must be previously floated to a smooth surface to receive the damp-course; the top of the waterproofing sheet must receive a safety coat of at least 2 in. of cement mortar, before the main body of concrete is laid down.

10. *Safety Coat:* This safety coat is to be made of one part cement and two and one-half parts good sharp sand; the object of this coat is to protect the damp-course from being punctured by the ramming of the rough or top bed of concrete.

11. *Resistance for Horizontal Damp-Courses:* Where there is considerable water pressure, the top bed of concrete should not be less than 18 in. thick; should the substructure be much below the low-water mark, sufficient concrete or reinforcement must be provided to resist the hydrostatic pressure.

12. *Drainage:* Water pressure is best relieved by the use of automatic siphons and sump-pit, together with tile drains, and wherever this is done, a decrease in resistance on top of the damp-course can be made.

13. *Materials Employed in Damp-Course:* All waterproofing must be done in the most approved manner, using (here specify materials desired) as (manufactured by).

Apply to all surfaces to be waterprooft, one heavy coat of (the material specified), care being taken that the surface to which it is applied is dry, and that the coating has been applied thoroly, and that no pinholes or other spaces are left uncovered.

Directly after this coat has been applied, lay the fabric to the surface of the same, pressing it down firmly, in order that the entire sheet may adhere to the wall; care must be exercised that the fabric is properly lapt, and that between the laps, sufficient waterproofing material is applied to cement them thoroly to each other.

Over the fabric apply one or more heavy coats of the material chosen, as conditions may require.

Properly connect the damp-course over the footings with that on the outer face of the wall and also with the damp-course over the cellar floor.

If the substructure is below low-water mark, increase the damp-course by adding such number of layers of fabric and additional coats of waterproofing material as the architect may direct.

SPECIFICATIONS FOR WATERPROOFING A PUMPING CHAMBER IN GROUND UNDER EXTERNAL HEAD OF WATER.

By the Use of Cement Waterproofing Compound—Integral Method.

1. *Intent:* It is the intent of these specifications to obtain a pumping-chamber free from the penetration of ground water so that the machinery employed therein will not be subject to corrosion due to the presence of water or moisture.

2. *Method of Procedure:* Watertightness shall be secured by proportioning the ingredients of the concrete composing the walls and floor of the chamber so that the voids in the same shall be reduced to the minimum as far as practicable, in accordance with the foregoing specifications, and by the addition to the cement of a dry powdered paraffinated waterproofing compound. In addition, the inner surface of the chamber walls and floor shall be surfaced with an unbroken continuous coat of cement mortar to which such waterproofing compound has been added. The compound, as manufactured by , or its equal may be used for waterproofing the cement or imparting to the latter its water-repelling properties.

3. *Proportions:* The proportion of the waterproofing compound in the body of the concrete work shall be not less than 4 lbs of compound to each barrel of cement employed for making this concrete.

4. *Surface Coat:* The surface coat shall be not less than 1 in. in thickness on the floors and ⅝ in. on walls, and shall consist of 1 part Portland cement and 2½ parts sand and 8 lbs of waterproofing compound to each barrel of cement employed in making such surfacing.

5. *Mixing:* The waterproofing compound must be added dry to the cement and the two thoroly mixt until a uniform mixture is obtained. Under no circumstances must the compound be added after the cement has partially set or has been mixt with sand. The sand shall be slightly moistened before mixing with the cement.

6. *Laying:* Great care shall be taken in placing the concrete so that maximum density will be secured. A wet mixture shall be used, the proportion being at least 1 part cement to 5 parts sand and stone or gravel.

7. *Uniting Old and New Concrete Surfaces:* Before laying new concrete upon old work, the surfaces of concrete already set shall be thoroly washt with material prepared for such purposes. This washing shall be followed by washing with water. Upon the surface thus prepared, the new concrete shall be laid. The "Bondsit" manufactured by the A. C. Horn Co. of New York City or its equal may be employed for this purpose.

8. *Laying the Surface Coat:* Great care shall be exercised in laying the surface coat of waterprooft cement mortar on the walls or floors. The concrete surfaces to which same is to be applied shall be clean and roughened or scratched if the engineer shall so direct, to secure a good bond with the surface coat. If ordered, the surfaces shall be washt as above described before the finishing coat is placed.

9. *Finishing Coat:* When the concrete, after being treated as above described, presents a thoroly satisfactory appearance, the finishing coat shall be applied or "floated" to the floor and walls by men especially skilled in this class of work, and a perfectly smooth, true and uniform plaster surface shall be obtained, free from cracks, blow holes, pin holes or other defects.

10. *Water Pressure:* Water pressure against the walls or floor of the chamber shall be relieved by draining and pumping if necessary until the surface coat is sufficiently hard and bonded to the concrete walls and floor so that it can resist said pressure by its own adhesiv power. An adequate drainage system shall be constructed satisfactory to the engineer, if the latter shall so direct.

11. *Approval of Engineer:* The surfaces of the concrete of the walls and floor shall be in a condition satisfactory to the engineer when the finishing coat is being applied, and said finishing coat is to be kept moist by spraying or otherwise, and protected from frost and sun while it is in the process of setting.

12. *Setting Time:* No walking or rolling of wheel-barrows will be permitted on the finisht floor of the chamber until the surface finish shall have been allowed to set for at least seven days, or longer if the engineer shall so direct.

By the Use of Coal Tar and Felt.—Bituminous Method.

1. *Intent:* It is the intent of these specifications to obtain a pumping-chamber free from the penetration of ground water so that the machinery therein will not be subject to corrosion due to the presence of water or moisture.

2. *Proviso:* The placing and protection of the waterproofing shall be done in accordance with the plans and specifications herein provided.

3. *General Description:* Waterproofing shall consist of an unbroken continuous bituminous shield, completely enveloping the walls and floor of the chamber. The vertical portion is to be erected against a brick or concrete wall at least 4 in. in thickness which has previously been bilt against the sheet piling employed for making and protecting the excavation. This shield shall be protected from injury during the laying of the concrete walls of the chamber by a protecting coat of cement mortar. The horizontal portion of the shield is to be constructed on an under layer of concrete, at least 6 in. thick.

4. *Materials:* The bituminous shield shall be made up of no less than four alternate layers of the best grade of tarred felt, cemented together with the best grade of coal-tar pitch. The coal-tar pitch shall be straight run, which will soften at 70° F. and melt at 100° F. The felt shall be a first-class quality, thoroly saturated with coal-tar or other material acceptable to the engineer.

5. *Condition of Surfaces:* All surfaces to be waterprooft shall be as smooth as possible and shall be dry.

6. *Laying:* On the prepared surface shall be laid a uniform layer of the melted pitch. Then first layer of the fabric shall be rolled out into the pitch while the latter is still hot, and prest against it so as to insure its being completely stuck over, and shall be free from all blow holes, pin holes, or other imperfections.

7. *Carrying Waterproofing Against Sheet Piling:* In case tung and grooved sheet piling is used for making and protecting the excavation and this piling has been treated with an efficient wood preservativ satisfactory to the engineer, the 4-in. brick retaining wall previously described may be dispensed with, and the wall waterproofing carried up against the sheet piling. The sheet piling shall be given a thoro coat of hot pitch and all points thoroly filled before the first layer of felt is placed thereon. Coppered Carbolineum or other wood preservativ satisfactory to the engineer may by used for protecting the sheet piling.

8. *Connections:* Great care shall be taken in connecting the fabric at the junction of the floor and walls, a lap of at least 12 in. to be allowed for same. The ends of the rolls of the floor fabric shall be brought up on the inside of the layer on the walls. Where it is necessary to stop work, a lap of at least 12 in. shall be provided for connecting on the adjacent portion of the work. Upon this layer of fabric shall be spread a second layer of hot pitch as before, and these operations continued until the requisit number have been placed, the last layer of felt being covered with a final coat of hot pitch.

9. *Protection:* The bituminous shield herein described shall be protected from injury by a coat of cement mortar mixt in the proportion of 1 part Portland cement to 2 parts sand, which shall be placed upon the waterproofing within 12 hours of the placing of the latter, or sooner if the engineer shall so direct. Should the waterproofing be injured, owing to failure of placing the protectiv coat of cement mortar, which injury is caused by exposure to weather, bulging from masonry surface or puncturing from any cause, the contractor shall remedy the same at his own expense.

10. *Placing the Concrete:* Concrete of the walls and floor shall be placed carefully upon the protecting mortar surface, care being taken not to injure the latter.

11. *Water Pressure:* The work shall be free from water pressure during the laying of the waterproofing, being relieved by draining, and pumping if necessary. An emergency sump shall be provided if ordered by the engineer.

12. *Skilled Labor:* Necessary working room must be provided for the proper execution of the work and none but men skilled in this work shall be employed.

13. *Caution:* No waterproofing shall be done when the temperature is below 25° F.

SPECIFICATIONS FOR WATERPROOFING PENNSYLVANIA-LONG ILAND RAILROAD TUNNEL.

The following are the specifications followed in providing for the waterproofing of the Pennsylvania-Long Iland tunnel:

1. In tunnels driven with shields, the cast iron shells will serve as waterproofing.

2. In tunnels driven in the ordinary manner without shields, the space between the side of the excavation and the neat line shall be filled with concrete behind suitable forms. After the forms are removed the surface of the concrete shall be given a half-inch coat of mortar containing equal parts, by volume, of Portland cement and sand and troweled smooth. After the mortar has set and dried out, it shall be covered with alternate layers of coal-tar pitch and felt, seven layers of pitch and six of felt. The felt shall be "Hydrex" felt, manufactured by F. W. Bird & Son, of East Walpole, Mass., or felt equally satisfactory to the engineer. The pitch shall be straight run coal-tar pitch, which will soften at 60 deg. F., and melt at 100 deg. F., being a grade in which distillate oils, distilled therefrom, shall have a specific gravity of 1.105. It shall be mopt on the surface of the concrete to a uniform thickness of not less

than $\frac{1}{16}$ inch. Immediately on this coat of pitch and while it is still melted, there shall be laid a covering of felt, the sheets to lap not less than 4 in. on cross joints nor less than 12 in. on longitudinal joints, and to be made to adhere firmly to the pitch-covered surface of the concrete everywhere. This felt layer shall be mopt with pitch as above described, another layer of felt then added and mopt with pitch, and the process continued to the full number of layers required. This waterproofing shall extend from the level of the bottom of the electric ducts to 15 degrees above the spring line of the roof arch. After the waterproofing has been placed the remainder of the concrete, with the electric ducts, etc., shall be placed.

3. Where roofs of tunnels driven in the ordinary manner without shield are of brick, they shall be plastered with a mastic containing coal-tar and Portland cement in such proportions as the engineer may from time to time require. This shall be applied with a trowel in a uniform layer half an inch thick, containing equal parts by volume of Portland cement and sand, and the joints completely filled with mortar of the same composition. The junction between the waterproofing in the roof and sides shall be formed so as to make a continuous waterproofing surface.

4. Where the roofs of tunnels are of concrete bilt solidly against the rock, the waterproofing of the roof shall consist of grout injected thru pipes bilt into the concrete at such intervals as the engineer may require.

5. Where tunnels are bilt by the cut and cover method, the sides, if in rock excavation, shall be waterprooft as described in paragraf 2; if in earth excavation, they shall be waterprooft as herein specified for roofs. The roofs of tunnels will be plastered smooth and covered with coal-tar and felt as specified for sides of tunnels in paragraf 2. The waterproofing shall be covered with a one-inch layer of mortar, containing equal parts, by volume, of Portland cement and sand. The mortar will be laid on in areas about 5 feet square and when one square is set, the adjacent ones will be laid tight to it, this laying out in squares being for the purpose of relieving expansion or contraction. A thoro connection shall be made between the waterproofing of the top and sides.

6. The waterproofing of retaining walls and portals shall extend from the base of the wall to within one foot of the top. Where the walls are bilt against the face of rock excavation, the waterproofing shall conform to the requirements for sides of tunnels in paragraf 2; where the wall is not bilt against a rock face, the waterproofing shall be the same as specified for tunnel roofs in paragraf 5.

7. Where the floors of tunnels or approaches are on rock, no waterproofing will be used in the floors except when specially required by the engineer, and will then be paid for at the rates named

in the schedules of unit prices. Where the floor is in earth, a layer of concrete 6 inches thick shall first be laid and covered with a half-inch coat of mortar containing equal parts, by volume, of Portland cement and sand, and troweled smooth, on which the waterproofing of pitch and felt specified in paragraf 2 shall be laid and the remainder of the concrete for the invert then added.

8. Waterproofing and the protecting mortar coat must be protected from injury by working or walking thereon, or during the filling of rock packing over tunnel roofs, or while placing back filling behind retaining walls.

SPECIFICATIONS FOR WATERPROOFING CONCRETE BRIDGES—CHICAGO & NORTH WESTERN RAILWAY.

1. *Material:* (a) Asphalt shall be used which is of the best grade, free from coal-tar or any of its products, and which will not volatize more than ½ of 1 per cent. under a temperature of 300° F. for 10 hours.

(b) It must not be affected by a 20 per cent. solution of ammonia, a 25 per cent solution of sulfuric acid, a 35 per cent. solution of muriatic acid, nor by a saturated solution of sodium chloride. It should show no hydrolytic decomposition when subjected, for a period of ten hours, to hourly immersions in water with alternate rapid drying by warm air currents.

2. *Range of Temperature:* (a)For metallic structures, exposed to the direct rays of the sun, the asphalt must not flow under 212° F., nor become brittle at 0° F. when spread thin on glass.

(b) For structures under ground, such as masonry arches, abutments, retaining walls, foundation walls of bildings, subways, etc., a flow point of 185° F., and a brittle point of 0° F. will be required.

(c) A mastic made from either grade of asphalt by mixing it with sand must not perceptibly indent when at a temperature of 130° F. under a load of 20 pounds per square inch. It must also remain pliable at a temperature of 0° F.

3. *Preparing Surface:* (a) Before applying asphalt to a metal surface, it is imperativ that the metal be cleaned of all rust, loose scale and dirt, and if previously coated with oil this must be burned off with benzine, or by other suitable means. The metal surface must be warm to enable the asphalt to adhere to it, and the warming is best accomplisht by covering it with heated sand, which should be swept back as the hot asphalt is applied.

(b) When waterproofing masonry structures, if the surface cannot be made dry and warm, it should be first coated with an asphalt paint applied cold. This is particularly necessary for vertical surfaces. It is difficult to make either cold or hot asphalt adhere to the surface of concrete or mortar when the latter is covered with a thin film of cement. To overcome this the surface of the structure should be covered with a finishing coat of mortar composed of one part of cement to one part of sand. If this is not permissible the surface should be cleaned with a sand blast.

4. *Preparing Asphalt:* The asphalt should be heated in a suitable kettle to a temperature not exceeding 450° F. If this is exceded it may result in "pitching" the asphalt. Before the "pitching" point is reached the vapor from the kettle is of a bluish tinge, which changes to a yellowish tinge after the danger point is past. If this occurs the material should be tempered by the addition of fresh asphalt. The asphalt has been cookt sufficiently when a piece of wood can be put in and withdrawn, the asphalt clinging to it. Care should always be taken not to prolong the heat to such an extent as to "pitch" the asphalt; should it become necessary to hold the kettle for any length of time, bank or draw the fire and introduce into the kettle a quantity of fresh asphalt to reduce the temperature.

5. *Application of Asphalt:* (a) The first coat should consist of a thin layer poured from buckets on the prepared surface and thoroly mopt over.

(b) The second coat should consist of a mixture of clean sand or limestone screenings, free from earthy admixtures, previously heated and dried, and asphalt, the proportion of 1 part asphalt to 3 or 4 parts sand or screenings by volume; this is to be thoroly mixt in the kettle and then spread out on the surface with warm smoothing irons, such as are used in laying asphalt streets. The irons should not be hot enough to burn the asphalt.

(c) The finishing coat should consist of pure hot asphalt spread thinly and evenly over the entire surface, and then sprinkled with washt roofing gravel, torpedo sand or stone screenings, to harden the top.

(d) The entire coating should not be less than 1 in. thick at the thinnest place.

COMPLETE DIRECTIONS FOR THE APPLICATION OF WATERPROOF CEMENT COATINGS.

Preparation of the Coating.—The "waterprooft coating" referred to below, may be prepared as follows:

A high-grade Portland cement passing all the usual requirements as to strength, soundness, etc., should be employed. To each

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NOTE.—It is advisable wherever possible to have the coating applied under a guarantee, by a waterproofing contractor specially skilled in this work, but in many cases this cannot be done. The following directions which are adapted from the specifications of the Winslow (Hydrolithic) Co., will result in a watertight job if concientiously adhered to.

100 lb. bag of cement there shall be added dry at least 2% of a first-class water-repellant compound of a floury consistency, such as are listed in the table on page 229. The exact proportion is to be obtained from the manufacturer of the particular compound employed. The cement and compound must be manipulated until a homogeneous mixture in every respect is obtained. The resulting *waterprooft cement* is then mixt with sand in the proportion of one part of cement to two parts of sand. The sand should be absolutely clean, containing no loam or foren matter, and well graded in size from course to fine. It is not necessary that the sand be sharp. The sand should be moistened, the waterprooft cement spread over it, and the whole manipulated until the ingredients are thoroly intermingled and a perfectly uniform and homogeneous mixture is obtained. This requires a great deal of care, but it is necessary if an efficient coating is desired.

Walls and Their Preparation.—All walls, such as enclose the general basement, and such as have footings beneath the basement floor, shall first be prepared by chipping off the entire skin of their inner basement surfaces, not more than two days ahead of the coating of them that is to follow. Thoro brushing of the chipt surfaces, with stiff wire brushes, shall next follow, not farther ahead of the coating work than twenty-four hours, to remove every particle of substance from the wall that may be loose and infirm. Following close upon the heels of the wire brushing, all deep crevices and holes shall be thoroly rinsed and slush coated, as will further be explained, and then filled—large voids with waterprooft concrete (waterprooft coating with clean, crusht rock or gravel), and small voids with waterprooft coating, the outer surfaces of which shall be left rough.

Immediately before the coating work begins, the chipt and wire broomed walls shall be thoroly rinsed and soakt with clean water. The water is to be impinged with force upon the walls (scrubbing with stiff brooms or scrubbing brushes may be substituted), to insure the removel of every particle of dust, and to thoroly soak, to its full hygrometric capacity, the material of which the walls are constructed.*

Following quickly upon the rinsing and soaking of the walls, but not so closely as to subject the freshly applied coating to the oozing of a possibly over-soakt piece of wall, the "slush coating" shall be applied. To prepare this, some of the mixt, ready-for-use coating shall be thinned with water to the consistency of thick cream. It shall be applied with a palmetto, or an equally strong-fibred scrubbing brush, with a scouring effect, care to be exercised to fully cover, in this manner, the inner surfaces of all crevices and holes.

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* NOTE.—No other than clean, clear water shall be employed by the waterproofer, either for cleansing of the surfaces to be coated or for mixing the coating ready for use. Not less, nor more, than eight gallons of water to four sacks (one barrel) of coating shall be employed to mix the waterprooft coating ready for application.

Application of Coating.—Quickly, before the slush coating can show markt signs of drying, the first application of the regularly mixt coating shall be applied (¼ or ⅜ of an inch thick) directly upon the slush coating, and pressure enough shall be applied to the trowel to push the coating home to the utmost limit of every unevenness, void or crevice that may by any chance or circumstance exist in the structural surface.

Endeavor must be earnestly exercised by the waterproofer to apply a second and final application of coating (¼ or ⅜ of an inch thick) before the first applied coating shall have reacht its final setting point. Should there be causes at any time to prevent this, then the first application shall be floated with a wooden float before it has reacht the point of its final set, and the surface so floated shall be thoroly scratcht or roughened. Then, before the final coating is applied to this scratcht portion, its surface shall be thoroly rinsed and slush coated in the same manner as has been described for this treatment of structural surfaces.

The finisht wall coating shall be of a flat, filled out, smoothly troweled surface, free from pits, pin holes, sagging cracks and all porous imperfections, and be of a full average thickness of ⅝ of an inch. It shall everywhere be thick enough to float and pack well, without any rolling of the grits in the coating. The floating shall be done at the moment when and while it may thus be packt and densified from top to bottom. Any portion of coating which becomes set before it has been floated shall be entirely removed from the structural surface by chipping, wire brooming and scouring, and the surface so obtained shall be re-coated with freshly mixt waterprooft coating before this portion of the work will be accepted.

The joining of one day's work to a previously applied and hard set coating shall be to straight edges, cut at the time when the older work is being finisht. To make the joining, the edge shall first be scrapt with the edge of a trowel or scraper; slush coating shall then be scrubbed into this edge, and fresh, regularly mixt coating shall be hard rubbed, back and forth, under the nose of a pointer trowel, into the preceding slush coat. This point shall again be well packt when the floating and the finish troweling takes place. The wall coating shall extend from El.   down to El.   , coincident with the bottom line of floor, if floor has not been laid; shall join floor coating with a cove or fillet, if floor has been laid and is itself to be coated; shall extend to floor line and out upon the same six inches, with cove or fillet in corner, if floor has been laid and is itself not to be further coated.

Steel Colums Imbedded in Walls.—(a) The granit, brick or concrete footing shall have 1 in. thick damp course of waterprooft coating laid and bonded to its top surface, and the same shall extend (4 in. if possible) beyond the shoe and structure enveloping the colum.

(b) The colum shall be imbedded in a concrete envelope, or surrounded by a hard, burnt brick and cement mortar wall, prior to the bilding of the main wall; the waterprooft coating shall cover the entire exterior surfaces of the back, sides and front of the envelope, connecting with the damp course beneath the base. After this, the main wall of masonry, or of concrete, shall be bilt between colums by the mason contractor and the connection between walls and colums shall then be made as shown upon drawings.

Basement Floors.—To withstand hydrostatic pressure, they shall be bilt by the waterproofing contractor, and shall be of such design, thickness and reinforcement as shown on plans. They shall be so thoroly constructed as to bear an unconditional three-year bonded guarantee to withstand a hydrostatic head of   feet.

This concrete shall consist of:

1st.—Four parts of washt, clean gravel that carries no sediment or clay, and which shall, for 60% of its bulk, be of sizes that shall range from 1½ in. to 1 in., and, for 40% of its bulk, shall range from 1 in. to and including ½ in. A strong, hard, crusht trap rock may be substituted for gravel, but limestone should only be selected when neither gravel nor trap is obtainable.

2d.—Three parts of clean, strong and hard Torpedo sand that carries no silt, clay, calcareous, micaceous, carboniferous, or vegetable substance. The grains of this sand shall, for 50% of the bulk pass a No. 6 foundry screen and rest upon a No. 14 screen; for the other 50% of the bulk, the grains that pass the No. 14 screen shall rest upon a No. 40 screen.

3.—One part of a high grade Portland cement, tested, for permanency of form, setting qualities and tensile strength, 90% of which shall pass a 200 mesh screen. The mixing of these aggregates shall be, if by machine, in a batch mixer, and water shall be added sufficient to cause an elongated ball, when molded and comprest in the hands, to hang together for a space of three seconds, if held suspended at one of its ends.

Hand mixing shall not be done unless performed on the following plan, and the architect may at any time order it stopt, and machine mixing substituted therefor, should he be of the opinion that the method of hand mixing is not being strictly observed and carried out as specified:

1st. The sand and cement shall be mixt together dry, without the gravel, and turned over and over until all parts of it shall have been thoroly commingled, as will be indicated when the color of the mix is the same thruout the entire mass.

2d. The gravel shall be spread upon the mixing platform in a parallelogram of even thickness. It shall then be thoroly drencht with water until it is wet thru and thru.

3d. The dry mixture of sand and cement shall be spread evenly over the surface of the parallelogram of wet gravel.

4th. The whole mass of gravel, sand and cement shall be shoveled, over and over, end upon end and side upon side, completely, three times; light sprinkling of water being given the while, with care being exercised to produce an exact and even dampening of the mass.

Twenty-four hours after the concrete shall have been laid its surface shall be prepared to receive the coating in the manner as has been specified for the preparation of walls, excepting that wire brushing or brooming will answer in the place of chipping, save only on patches where the tamping brings neat cement to the surface and leaves it to become a hard, smooth glaze. Such patches shall be chipt until every vestige of the glaze is removed. The rest of the procedure for coating the floor shall be exactly as described and specified for wall coating, excepting that the workmen who will be engaged in cleaning, slush coating and plastering the floor surface, shall not pass to a cleaned and prepared-for-coating space, without first carefully cleaning and rinsing the soles and heels of their shoes.

The contractor shall provide and install a system of under drainage, beneath the floors, amply capable, at all times during construction, of accommodating the flow of water to one or more pump sumps in such a manner as to positivly preclude any possibility of a rise of water into the concrete during the construction and waterproofing of the floor. The sump, or sumps, shall be waterprooft and so constructed as to be capable of a tight seal at the close of operations, and yet such as may be opened at will, at any future time. These shall be set in the concrete of the floor and in connection with the under drainage, in the manner as shown in the detail drawings for this feature in the floor construction.

The waterproofing shall be a 1 in. thickness of waterprooft coating, applied as a wearing surface to the concrete base of the floor, not earlier than twenty-four hours nor later than forty-eight hours after the concrete shall have been laid and tampt in place.

Testing for Soundness.—When all coating, both on wall and floor, has become hard and firm (three to five days being allowed therefor), it shall then be tapt or sounded by the architect or his superintendent, a light hammer being used, and any hollow or shelly places thus revealed shall be entirely cut out with sharp steel points, and recoated. The bond of the coating to floor or wall shall at every point of contact be firm and sound.

Machinery Foundations and Anchors.—Where such foundations are to be within or beneath a basement floor, they shall be a monolithic part of the same, and all anchor bolts shall be set in waterprooft sockets, and these shall be set in the concrete at the time it is placed in position. Templates for the proper positioning of such sockets will be supplied.

Treatment of Interior Colums.—Such as will have their bases below the finisht waterprooft surface of the floor shall have their granit, brick or concrete footings topt with a damp course of a 1 in. thick waterprooft coating, extending beyond the metal bases, or shoes, of colums at least two and if possible six inches. The floor construction around such colums shall form a wall, or pit, whose depth shall coincide with the thickness of the floor, the latter overlapping four inches the damp course that will have been laid on top of the footings of the colums in question. The floor waterproofing shall extend from the top surface of the floor over the sides of the pit, connecting with the damp course on the top of the footings, which latter will constitute the floor of the pit.

The pits about the colum bases shall be closed by slabs of concrete or metal covers, the top surfaces of which shall coincide with the general surface level of the floor. They shall be capable of removal at will.

Treatment of Girders Entering Outside Walls Below Water Level.—The top of the wall, whereupon such girders will rest, shall be coated with a thickness of three inches of waterprooft coating, extending three inches beyond the edges, ends and sides, of the beam. After the beam, or girder, shall have been placed in position, that part of the member which will overlap the wall must be wholly envelopt in a uniform, 3-in. thickness of waterprooft coating, ends, sides and top, this envelope to be bonded, as described for joints on walls, to the 3-in. base of waterprooft coating.

Treatment of Pipes and Condits Piercing Floors or Walls Below Water Level.—Steam and hot water pipes, or any pipes at all that will be subject to considerably varying temperatures, and therefore to consequential degrees of expansion and contraction, shall be provided with waterprooft expansion accommodators, to be set, if possible, at the time of placing the concrete, whether for floor or wall.

All other pipes or fittings piercing either floor or wall must be sandblasted, emeried, or otherwise made bright, with every vestige of paint, grease, or other foreign substances removed from their contact surfaces, and be set in the concrete structure with waterproof coating. This should be done at the time of placing the concrete in position, but may be done afterwards, when holes may have to be cut thru the concrete for the purpose.

Guarantees.—All work shall bear a three-year bonded guarantee, absolute and unconditional, if the supporting structure be bilt by the waterproofer, but modified by and limited to indisputable settlement, weakness or instability, if the supporting structure is constructed by other than the waterproofer.

Old, Completed Structures, Whose Waterproofing Is Faulty or Which for Other Causes, Need Waterproofing.—Generally speaking the specifications for old bildings, tunnels, etc., or those completed without waterproofing, are about what would be necessary for new work, but there are a few conditions which require special handling.

Treatment of Interior Colums with Bases Below the Surface.—The colums are either to be temporarily removed for a bilding up of their footings above the floor level, with the waterproofing of the bilt up structure in continuity with that of the floor coating, or else they must be encased with an envelope of waterprooft concrete, based on the floor and rising to a level above that of high water.

Treatment of Colums Partially Encased in Outer Walls.—The investing material must be cut away from the colum at least three inches back toward the outer surface of the wall, and the under surface of the floor, and that part of the colums thus denuded must be cleaned to brightness; the brightened surfaces of the metal and the surfaces of the cut-away parts, must be scoured with slush coating, and the cuts filled with the ordinary mixture of waterprooft coating. This in turn must connect with the coating upon walls and floor.

COMPOSITION OF SOME OF THE WATERPROOFING COMPOUNDS IN USE.*

In the "Sylvester's process" a hot solution of soap, prepared by dissolving ¾ lb. of Castile soap in 1 gallon of water, is first brusht over and into the surface of the concrete, and allowed to dry for 24 hours. At the end of that period a second wash, consisting of 2 oz. of alum dissolved in 1 gallon of water, is applied in the same manner. The alum solution should be at a temperature of from 60° to 70° Fahr. The double operation is to be repeated as often as necessary or desirable, but four such coats are said to be impervious to a head of 45 ft. of water.

In "Handbook for Superintendents of Construction, etc.," the following cement wash is recommended for making a water-tight lining for cisterns: A stock solution is prepared of 1 lb. "lye," 5 lb. alum dissolved in 2 quarts of water. One pint of this solution is stirred into a pail of water containing 10 lb. of cement, and the mixture is applied to the surface of the concrete with a brush.

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* Compiled in part by Gadd.

Another method is to apply a rendering composed as follows:

1. Portland cement 1 part, sand 1 part.
2. Portland cement 1 part, sand 2 parts, lime paste ½ part.
3. Portland cement 1 part, sand 3 parts, lime paste 1 part.
4. Portland cement 1 part, sand 5 parts, lime paste 1½ parts.

The surface of the rendering, composed according to one of the above formulas, is brusht with a solution of 1 lb. "concentrated lye," 5 lb. alum, and 2 gallons water, in the proportion of 1 pint of this solution to 5 lb. of cement.

In principle the above-named methods are alike, and all depend upon the precipitation within the surface pores of the concrete, or outer coat, of insoluble alum soap, or hydrate of alumina, or both together. The last-named example, however, combines to some extent the method of pore-filling in bulk with sand and lime paste.

In "Plastering, Plain and Decorative," Miller recommends painting the surface of the work with a hot mixture prepared by mixing 20 lb. of chopt suet with 1 bushel of lime, and stirring up with boiling water.

Professor Hatt states that with a mortar composed of 1 part of cement to 2½ parts of bituminous ash, when alum and soap were mixt with the water used for gaging, the strength and hardness increast 50 per cent. and absorption decreast by the same amount. One half of the water used for gaging was a 5 per cent. solution of ground alum, and the other half was a 7 per cent. solution of soap. The alum solution was used first.

Cunningham proceeds on similar lines. He uses powdered alum equal to 1 per cent. of the combined weight of sand and cement. To the water used in the mix he adds 1 per cent. of yellow soap.

Hawley employed a stock solution of 2 lb. caustic potash, 5 lb. powered alum, and 10 quarts water. A finishing coat was made with 3 quarts of this solution in each batch of mortar containing 2 bags of cement. The mortar was made with 2 volumes of sand to 1 of cement, and the work covered to a depth of ½ in.

Marsh gives the following as a waterproof coat or rendering: 2 lb. soft soap, 12 lb. alum, 30 gallons water per cu. yd. of the mortar. Or, 2 lb. caustic potash, 5 lb. alum, 10 quarts water. Of this solution 3⅔ quarts are used for 2 bags of cement and twice its volume of sand.

It will be observed that these processes again depend upon the precipitation of aluminium soap or of hydrated oxide of aluminium, the only difference being that, in these cases, the precipitate is mixt with the mortar instead of being deposited at the surface of the hardened material.

Gaines, in a paper recently publisht, states that watertight concrete can be made (1) by replacing the mixing water with a dilute solution of a suitable "electrolyte" (*i.e.*, a 1 per cent. or 2 per cent. solution of alum); (2) by replacing 5 per cent. to 10 per cent. of the cement with dried and finely ground colloidal clay; (3) by combining methods (1) and (2). With regard to the second of these processes, the action appears to be simply one of pore-filling with fine particles of clay, inasmuch as no "electrolyte" is used; and in the other cases it is probable that the same kind of action takes place by precipitation of alumina, from the "electrolytic" solution, by calcium hydroxide, whether the electrolytic theory itself be correct or not.

It may be remarkt that the use of pulverized clay for this purpose is old.

"Lux," Patent No. 4606 of 1904. This material is prepared by pouring over 100 kilos of cement clinker (unground) 10 litres of boiling water containing 245 grams of stearine, 12 grams of potash (presumably caustic potash, altho it is not clearly stated), and 10 grams of colophony (*i.e.*, common resin).

Gallagher's Waterproof Compound.—This material is to be added to cement in the proportion of 2 per cent. to 5 per cent. on the weight of dry cement before mixing with the sand and water. Its composition has been stated to be chiefly lime and magnesia, with about 3 per cent. of stearine or other fatty acid.

"Pharos" waterproofing compound is composed of the following:

		Per cent.
	Free fat (tallow or stearine)	20.22
Lime soap	Combined fatty anhydrides	14.55
	Combined lime	1.57
	Lime	30.45
	Magnesia	21.15
	Hygroscopic water	3.32
	Combined water	5.77
	Silica	1.17
	Alumina and ferric oxide	1.18
	Sulfuric anhydride, etc	.62
		100.00

Cold bituminous dampproof paints, such as Horn's Dehydratine, Toch's R. I. W., Antihydrine, etc., for use on the interior surfaces of exposed walls or for exterior of foundations not subject to water-pressure. These are made up of specially selected asphalts dissolved in carbon bisulfide or some kindred hydrocarbon, the proportions varying according to the use to which same is to be put.

Paraffine, or other mineral substances, dissolved in gasolene with the addition of resin as a hardening agent, proportions varying according to use. This is employed for surface application to walls, etc., that are to be rendered watertight. Trade names: Dehydratine, Waxol, Anhydrol, etc.

Hydratite, Medusa, Maumee, Whitehall, Toxement, etc., and similar powders in very finely divided state. These are metallic starates to which are added varying proportions of hydrated lime, alum and clay. Two per cent. of the compound is usually added to 1 bag of cement before the addition of water.

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DISCUSSION.

Mr. Robert Ridgway.—I do not think the author in his paper has exaggerated the importance of his subject. All of us who have had to do with the waterproofing of masonry structures know what a difficult proposition it is. Perhaps some of you will tell us about your troubles in this direction. The Public Service engineers present can discuss it, I am sure.

Mr. George A. Taber.—It may be interesting to those who have not been intimately connected with work of this character, to obtain some data on the cost of waterproofing on a large scale.

The following figures were obtained from the work done on a portion of the Rapid Transit Subway, on Lenox Avenue, extending from One Hundred and Tenth Street to One Hundred and Thirty-fifth Street, which was under the supervision of the speaker in 1901 and 1902. This portion of the subway is of two-track, beam tunnel, cut and cover construction, about 28 ft. wide and 17 ft. high, the bottom varying from 4 to 6 ft. below ground water level.

Except near One Hundred and Twenty-fifth Street, where there is a summit in the grade, the bottom and sides were protected with 4-ply waterproofing, consisting of four thicknesses of asbestos felt, with five coats of asphalt, laid on hot with a mop. On the bottom an additional layer of dry felt was first laid, as good results could not be obtained by putting the first coat of hot asphalt directly on the damp concrete. This layer was not counted in the thickness of the water-proofing, being laid for convenience only, but its cost is included in the data given. The roof was covered with 3-ply, as were the bottom and sides, near One Hundred and Twenty-fifth Street, consisting of three layers of asbestos felt with four coats of asphalt.

The total amount of waterproofing laid, from which these figures were obtained, was 61 120 sq. yd. The details of the cost are as follows:

Items.	4-Ply.		3-Ply.	
	Total Cost.	Cost per sq. yd.	Total Cost.	Cost per sq. yd.
Labor	$5 998.75	$0.168	$2 573.00	$0.101
Materials	18 813.52	0.529	9 524.86	0.374
Small Plant and Supplies (Estimated as 5% of labor cost)	299.95	0.008	128.75	0.005
Superintendence (Proportion of superintendent of total work chargeable to this item)	1 453.05	0.041	753.57	0.030
Total cost	$26 565.27	$0.746	$12 980.18	$0.510
Amount of waterproofing laid	35 687 sq. yd.		25 483 sq. yd.	

Mr. Gardiner L. Van Dusen.—About ten or twelve years ago I had occasion to make some investigations in regard to the lining for a reservoir dam. The dam was of earth, lined with paving blocks, and considerable trouble was experienced with leakage. Some attempt was therefore made to provide a waterproof coating. On account of the character of the dam, it was necessary that this coating should have considerable tensile strength, and for that purpose a very thick coating was made of asphalt concrete. Gravel and sand and broken stone were used, varying from 1 in. in diameter down to very fine sharp sand, and all were thoroly cemented together by an asphalt mastic. This was then laid on the surface of the dam to a thickness of 4 or 5 ins., the thickness being necessary to provide the proper strength to withstand the distorting forces present, in addition to the purely waterproofing qualities. One great trouble found with this covering was that during the hot part of the summer it showed a decided tendency to soften and creep, thus considerably reducing its efficiency. Still, altogether, it proved quite satisfactory. I have not heard since as to the length of time that particular coating has remained in efficient use, or to what extent such a coating has been used elsewhere. Perhaps Mr. Lewis can give us some information in regard to it.

Mr. Lewis.—I wish to say that some of the railroads in recent bridge work have taken to the use of a bituminous concrete, similar to that which Mr. Van Dusen has described, and they find that in places where the vibration is very great, the use of such a material is better than ordinary concrete or any cement mortar which can be made, because a bituminous concrete possesses quite a good deal of elasticity as well as strength. If, in addition, several layers of felt and pitch, or asphalt, are added to the bituminous concrete, the ideal conditions for a more durable job are obtained, under which the least failure might be expected. I do not think that in modern railroad bridges, the waterproofing will remain tight more than say fifteen or twenty years, considering the heavy loads and the pounding to which they are subjected. The bridge work referred to in the paper is only about two years old, and the officials of the various roads are watching the results with a great deal of interest. While the results are so far satisfactory, no one can say that the work will be tight indefinitly. While talking about permanency, I may say we ought not to look for absolute permanency. We do not look for it in steel work; we paint our steel work to protect and preserve it. We do not look for permanency in timber work; if we want to prolong its life, we creosote it or treat it in some other way. There is no reason why we should complain because waterproofing will not last a thousand years. There is no more reason why waterproofing materials where practicable should not be renewed in the course of ten, twenty-five or thirty years, if the same becomes necessary, than there is in the case of steel or timber work.

If we can get a life of ten, fifteen or twenty years out of the materials, the cost of the waterproofing per annum, per unit, becomes so small that it pays for itself by the immunity from decay or corrosion of the structure during these periods. I think that the critics of waterproofing are unreasonable in asking that the materials should last forever. The elements are too much opposed to anything lasting forever and we ought to be satisfied with a reasonable length of life.

Mr. Van Dusen.—In the case of which you speak, the bituminous concrete was covered, was it not, in order to somewhat eliminate the effects of heat and great changes of temperature?

Mr. Lewis.—In the case of the bridge work, where felt and asphalt formed the top waterproofing layer, a cement mortar coat about 1 inch thick was placed over it, in order to protect it from abrasion in laying the ballast, as well as from other injurious influences. This is a precaution, the neglect of which has often caused a great deal of trouble. The protection coat omitted and a mass of concrete rammed up against the waterproofing, a hole is made thru which water finds its way, and the result is a leaky structure.

It is here that we note the great advantage of the "Integral" method of waterproofing, particularly in case of bilding substructures, for if a leak does develop, it is not necessary to excavate in order to locate it, and it can be remedied with much less trouble. In the reservoirs mentioned, the bituminous coating was covered with 4-in. of concrete to prevent injury from temperature changes and other causes.

Mr. Van Dusen.—I would like to say, in this connection, that at the time the investigations were made, I made several tests on beams of different sizes and combinations of this bituminous concrete, with the idea of strength in view, and found it gave very satisfactory results. These tests showed a very high degree of strength in the material and proved conclusivly that it could be used very advantageously in cases similiar to the one spoken of. As I said before the principal trouble in this particular case was occasioned by the creeping of the mastic, which caused more or less of a disintegration of the concerts, gave a very unsightly appearance to the dam, and considerably lessened the efficiency of the material. This effect was not serious, however. Altogether it seemed to be a very satisfactory material.

Mr. Lewis.—I would suggest, in that connection, the use of expansion joints similar to those used in laying the concrete lining in the reservoir at Mansfield, Ohio, which was shown on the screen. Furthermore, a high melting point material should be employed.

I have no dout of the strength to which you refer, as in the tests which I have made, the bituminous concrete set up very hard and tough.

MR. RIDGWAY.—In the designs of the Board of Water Supply for the Olive Bridge and Kensico dams, it is recognized that the mass of masonry will contract and expand, these movements resulting in cracks. Provision has, therefore, been made for expansion joints and a system of drainage which will take care of whatever leakage there may be, without resulting harm to the structures.

MR. EDWIN H. THOMES.—I would like to ask what tests are usually specified to insure durability? There is such a difference in bituminous compounds of asphalt, coal tar, etc. What tests do they usually apply?

MR. LEWIS.—The tests specified are usually the specific gravity, the percentage soluble in different liquids, generally some kind of hydro-carbon, the percentage of bitumen and uncombined carbon, and the freezing, softening, melting and boiling points; the flash point, color of vapor and odor are also serviceable tests.

Some of these tests are given in detail in the specifications accompanying this paper. As the requirements of different jobs vary so much, no set of tests applicable to all conditions can be given. The accompanying specifications sufficiently indicate their character. For instance, coal tar is a good deal more brittle than asphalt when it is exposed in cold weather, while, on the other hand, I believe coal tar is much more durable than asphalt if well protected. We know that illuminating gas, vegetable oils, and as in the instance I mentioned, possibly certain constituents of sewage have an injurious effect upon asphalts and the tests must be prescribed to suit the conditions. I believe the Rapid Transit specifications say that 95% of the asphalt must be pure bitumen. Is that right, Mr. Ridgway?

MR. RIDGWAY.—That is my recollection.

MR. LEWIS.—Some of the other specifications call for 80% and 85%. They vary largely. A low flash point in asphalt and a petroleum smell indicates adulteration or an oil asphalt which is objectionable. A high percentage of uncombined carbon in coal tar pitch is also objectionable. A series of tests for coal tars have recently been publisht by the U. S. Department of Agriculture, Bulletin No. 34, office of Public Roads, by Prevost Hubbard, which give valuable information on the subject.

MR. RIDGWAY.—Any member who would like to submit a written discussion on this important paper should do so, and it will then appear in the printed Procedings. As there are many here well qualified to do this, I suggest that it be done. The subject is a large one and not all has been said on it.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 45.

PRESENTED DECEMBER 23D, 1908.

THE ST. GEORGE FERRY APPROACH AND REINFORCED CONCRETE RETAINING WALLS.

BY MR. LOUIS L. TRIBUS,* MEMBER OF THE SOCIETY.

WITH DISCUSSION BY ROBERT RIDGWAY, C. D. THOMAS, RUDOLPH P. MILLER, GEORGE W. TILLSON, ARTHUR S. TUTTLE, AND THE AUTHOR.

One of the serious problems which confronted the city administration in January, 1902, was that of transportation between the Boros of Manhattan and Richmond. It had always been one of the interesting and important questions, but became eminently so when the revised charter gave a considerable measure of home rule, encouraging local development, which in turn began to be fostered, by the general city government, in a manner commensurate with Richmond's prospectiv importance as a part of the great city.

In the early half of the nineteenth century regular ferry service was establisht between Staten Iland and the then City of New York, a service that gradually increast, until two separate lines were in operation, one skirting the east short of the iland, stopping at various places, and the other similarly serving the needs of the north shore.

The late Erastus Wiman conceived the project of consolidating these ferries and operating them in connection with the Rapid Transit Railroad system, which would make a collection of passengers along both shores, as the line of railroad extending thru the iland from Clifton to Tottenville, would from the inland communities. St. George, or the nearest point to New York City, was selected as the terminal. It had two merits: First, as just stated, being the nearest point to New York City, and second, thru the effect of tidal action, absolute freedom from floating ice in the winter season. When some ten years later the electric railroads also took their place in serving the needs of the people, a further concentration of traffic at St. George resulted.

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* Commissioner of Public Works and Consulting Engineer, Boro of Richmond New York City.

For passengers the change thus made was a vast improvement on preceding conditions, but for team service it not only lengthened very greatly the distance to be traveled in reaching the ferry point, but, coming from New York, it entailed the climbing of a considerable hill for teams going in practically all directions. Yet for nearly twenty years these conditions obtained without relief. Various civic and official bodies devoted a great deal of attention to a study of the case, but practically all, with view to securing better ferry facilities in the shape of improved boats, more frequent trips, and lower rates of fare, than to a radical departure in method of serving the community.

One of the first official acts of the administration coming into power in 1902 was to see what could be done towards a full and final solution of the ferry transportation difficulties. It was finally decided that three ferries should be establisht; one great one at St. George or vicinity; the second at Port Richmond or West New Brighton, and a third at Stapleton or Clifton. Much discussion as to precise locations resulted, many being in favor of establishing the main ferry at Tompkinsville instead of St. George. All ultimately agreed on Stapleton and Port Richmond as the two places for the secondary ferries.

As between Tompkinsville and St. George, there were many arguments in favor of each location. On a close comparison, however, it was found that the Tompkinsville site would nearly equal in first cost that of St. George, while the space was not as available for the purpose, and two or three minutes would have to be added to the time of each boat's trip; as also two or three minutes more to all north shore passengers, with scarcely any saving to those from the east and south. While the traffic coming from the east side

PLATE 84.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
TRIBUS ON THE ST. GEORGE
FERRY APPROACH.

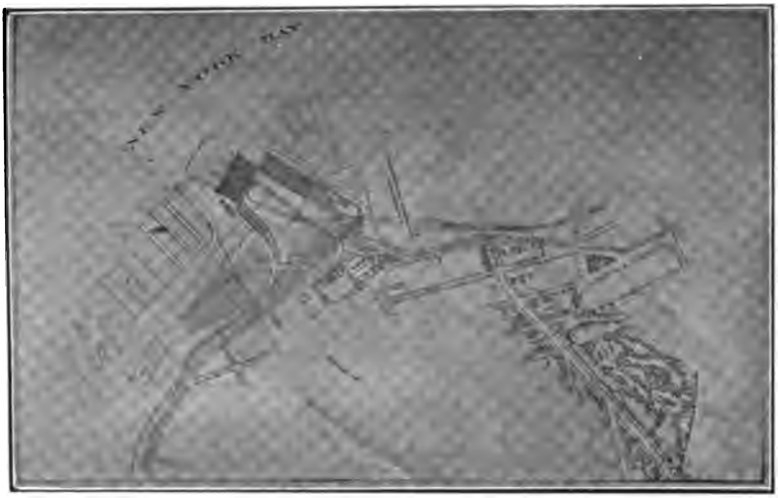

FIG. 1.—PLAN OF FERRY APPROACH STREETS, AND PROPOSED NEW OCEAN VIEW PARKWAY.

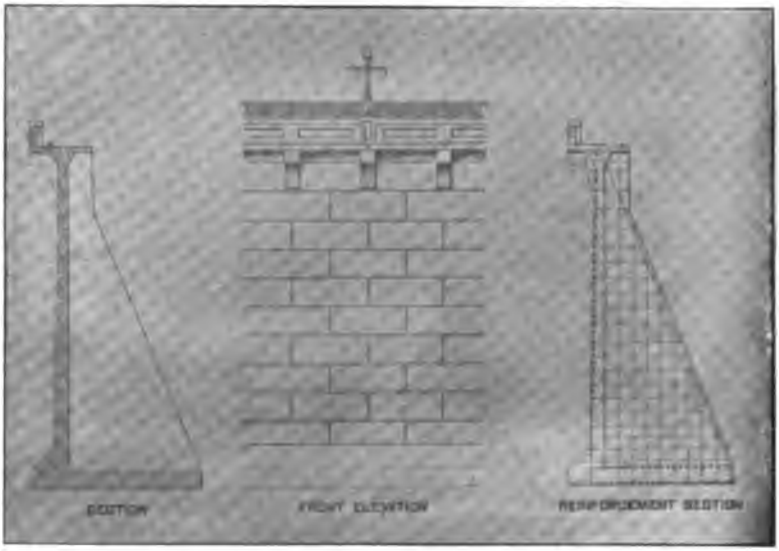

FIG. 2.—TYPICAL VIEWS OF THE ST. GEORGE FERRY APPROACH REINFORCED CONCRETE RETAINING WALL.

PLATE 85.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
TRIBUS ON THE ST. GEORGE
FERRY APPROACH.

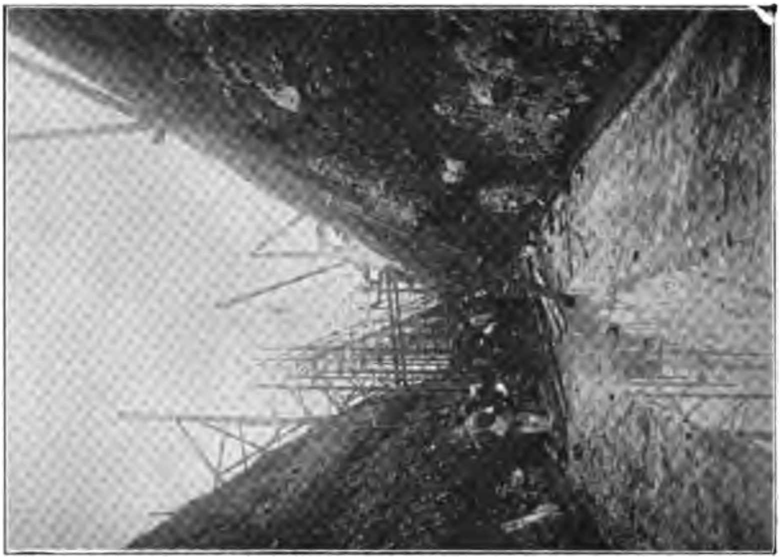

Fig. 2.—Assembling Steel Skeleton in Trench.

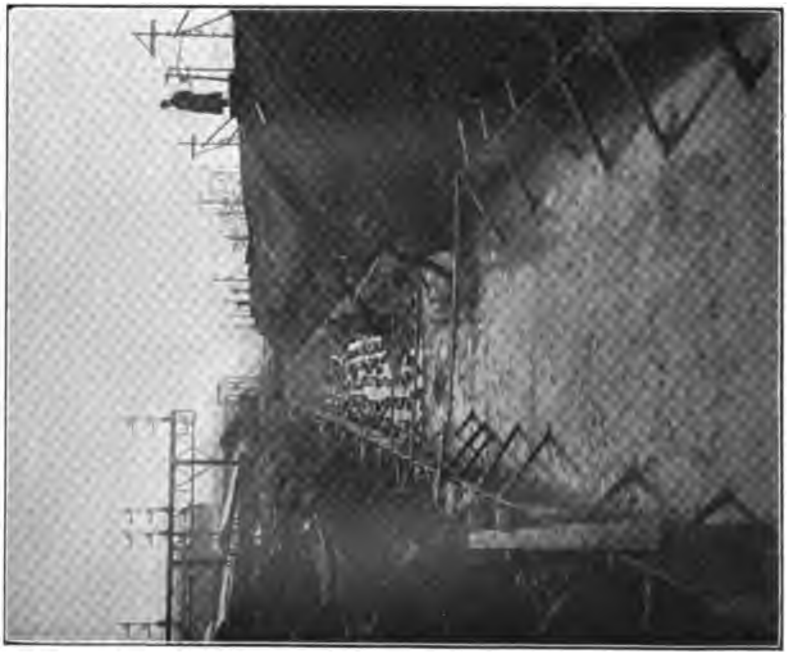

Fig. 1.—Pile Foundation for South Street, Westerly Wall.

of the boro could reach Tompkinsville without encountering heavy gradients, all teams coming from the north shore would have steep streets to traverse. The plan, therefore, was promulgated by the boro officials, of rectifying the grades approaching St. George so as to make 4% the maximum instead of 9% as then obtained. To accomplish this result, a radical improvement was necessary; fortunately the general administration lookt upon the project with a broad and sympathizing view; and the work described in this paper became possible.

The city, in obtaining property at St. George for the ferry terminal, acquired sufficient land in addition to widen both South Street and Jay Street from 50 ft. to 100 ft., and by an act of Congress the United States Dep't. of Commerce & Labor was authorized to sell to the City, upon appraisal, a portion of the unused property in the care of the Lighthouse Department; and thru condemnation procedings other properties are being acquired, title to which latter has been vested in the City in advance of confirmation, by resolution of the Board of Estimate and Apportionment, for the widened and new thorofare of 100 ft. width to the south. (See Plate 84, Fig. 1.)

An easy incline from the ferry gates reaches to South Street, which at that same grade, extends at widths of 70 and 100 ft. to Jay Street, which branches to the northwest as a 100-ft. thorofare for nearly half a mile to Richmond Terrace. South Street continues to Stuyvesant Place, which latter, thru the lighthouse property and its own widening, extends nearly one-half mile to the south, also as a 100-ft. thorofare. At the highest point, the present street surface will be cut down some 10 ft., so that the maximum climb for teams going to the east shore will be 50 ft., and to the north shore 38 ft., with, as before stated, 4% as the maximum grade, and that being for only about one-ninth of the whole improvement.

On South Street, from the Rapid Transit tunnel to the ferry gates, the incline has a 9½-ft. sidewalk and a 40½-ft. roadway, it being considered somewhat of an advantage to concentrate the traffic to and from the ferry, in lines, rather than to permit of a straggling approach. From the ferry gate, therefore, up to and along a portion of South Street, and along Jay Street to Richmond Terrace, there became necessary a large retaining wall. To preserve to the public the use of the full right of way, the wall has been designed with a part of the sidewalk overhanging and supported upon brackets, somewhat upon the principle of a cantilever. On the easterly side of the incline to the ferry, there being no sidewalk planned for, the wall is almost vertical from base to parapet.

On the portion of the new thorofare going to the south, the street will be somewhat below the level of the adjoining properties, but only ordinary retaining walls will be constructed. From a little north of the intersection of this new street with Weiner Place, a retaining wall of the reinforced type will be required for a distance of 800 or 900 ft. At Weiner Place it will have an overhang of about 9 ft., but brackets alone will not be trusted to carry the superimposed load; heavy I beams therefore will be imbedded in the work and carefully anchored. The need for this great overhang is to give the railroad company free headroom for an additional track, the city only acquiring an overhead easement for a portion of the street, rather than fee in the land.

The general plan also contemplates the full improvement of these streets, aggregating four-fifths of a mile in length; with smooth pavements; substantial, fine cut curbing; two 20-ft. sidewalks, each having 12 ft. paved with artificial stone, leaving space for 8-ft. grass plots and staggered rows of trees; ornamental electric lamps; at the intersection of South and Hyatt Streets and Stuyvesant Place, a small triangular park and fountain; and at the intersection of Arrietta and Griffin Streets and Stuyvesant Place extended, a larger triangular park.

In taking up the studies for the different retaining walls needed, which would vary in hight from a minimum of 10 ft. to a maximum of about 45 ft., many types were considered;—rough rubble masonry of gravity section; monolithic concrete of gravity section; combination of heavy rubble and cut stone; reinforced concrete with cut stone facings; and that which was finally selected, after years of study—a so-called reinforced concrete wall, but more truly a wall made of steel rods, enclosed in concrete for protection and as slabs to retain the earth embankments. (See Plate 84, Fig. 2.)

Many test pits were dug and borings made to determin the foundation conditions, as also tests of the compressibility and

PLATE 86.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
TRIBUS ON THE ST. GEORGE
FERRY APPROACH.

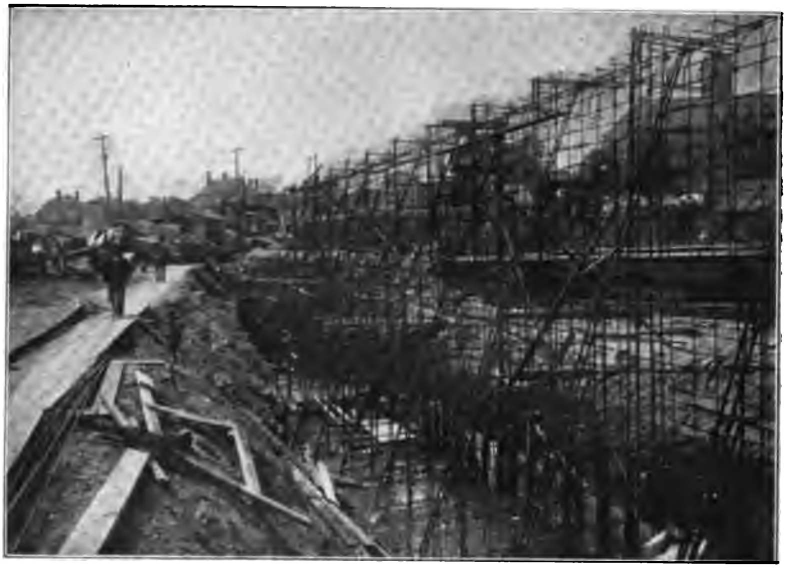

FIG. 1.—INNER SIDE OF SOUTH STREET, WESTERLY WALL.

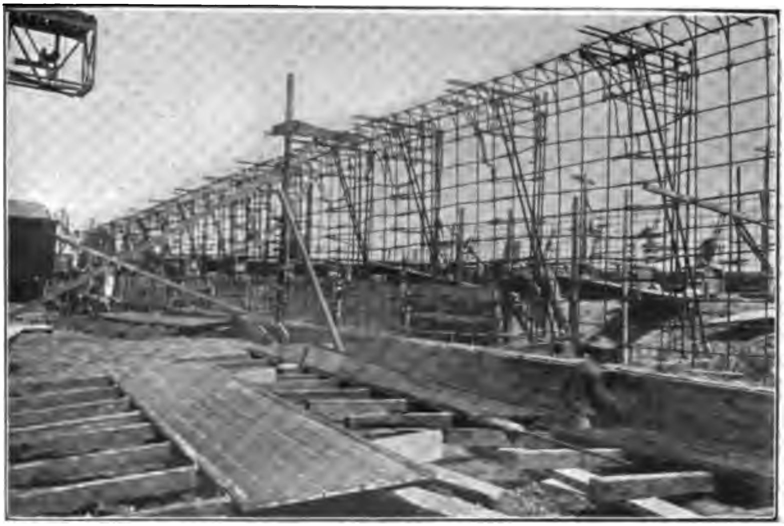

FIG. 2.—VIEW OF OUTER SIDE OF STEEL SKELETON, SHOWING BRACKETS AND COVE

PLATE 87.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
TRIBUS ON THE ST. GEORGE
FERRY APPROACH.

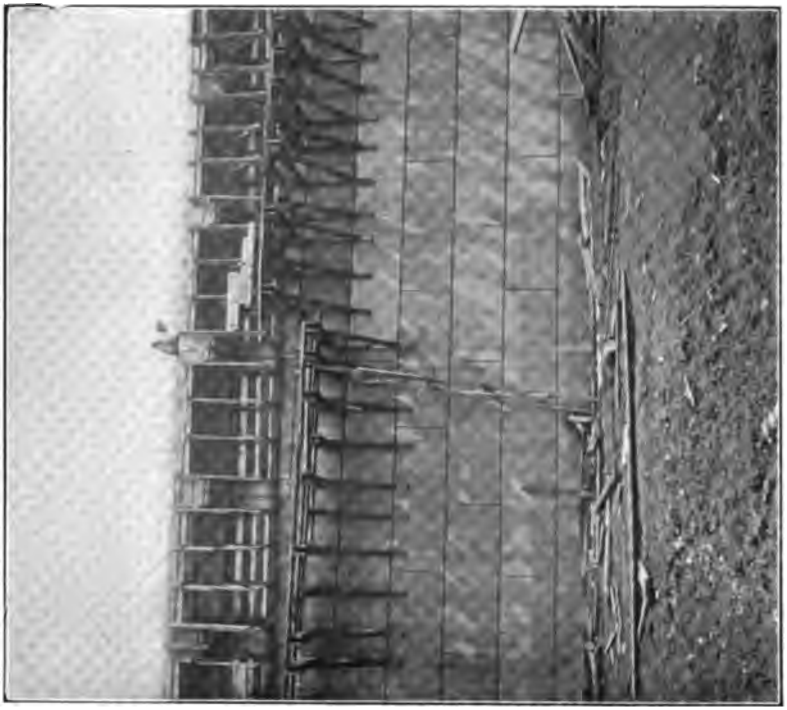

FIG. 2.—SCAFFOLDING AND BRACKET AND COVE FORMS.

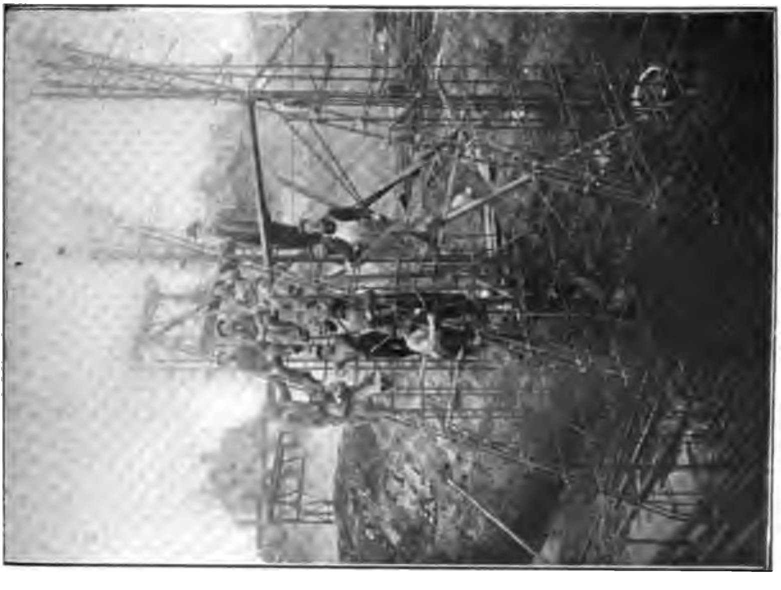

FIG. 1.—COUNTERFORT FRAMES AND BASE REINFORCEMENT.

suitableness of the materials encountered; years of observation gave good information as to the average angle of repose of the embankments to be supported; laboratory tests were made of various types of deformed steel bars so as to select the forms that would give the closest union with concrete.

In some places pile foundations were found to be desirable, but in general a form of hard-pan or rock was reacht at the depth selected for the base course. On the South and Jay Street walls, the determining factor was the level of the railroad yard; so that the foundation slab was put in place at the level of mean high water, which is about 5 ft. below the track level at the northerly end of the railroad yard and somewhat more than that at the southerly end. (See Plate 85, Fig. 1.)

Following excavation, a 3-in. layer of concrete was placed, of the requisit width for the varying hight of wall. On this the steel of the counterforts was assembled horizontally and fastened with clips, then erected and supported in position; vertical and horizontal face rods were then placed in position and fastened, after which the lower and upper courses of base rods were secured. The concrete base was then completed, acting as an anchor for the steel work; following which, concrete for the counterforts and face wall was put in position simultaneously in hights of 3 ft. (See Plate 85, Fig. 2.)

The design of the steel frame work is such as to develop almost entirely tensile rather than compressiv strains, and great care has been taken in the alignment of the steel skeleton. So stiff and rigid has it been made by wiring together all intersecting bars that it has been used by the contractor to carry the mold forms, which were raised section by section as the concrete set in place to form the walls. (See Plate 86, Figs. 1 and 2; Plate 87, Fig. 1, and Plate 88, Fig. 1.)

Joint-strips were fastened to the outer molds, so that the finisht work simulates "ranged ashlar" in blocks 3 ft. in hight by 8 ft. in length. (See Plate 87, Fig. 2.) As soon as the concrete had thoroly set, and immediately upon the removal of the form, the outer face was rubbed smooth with brushes and carborundum stones, together with a thin coat of pure cement grout. On final completion, the whole surface was cleaned with water and carborundum stones to remove stains, etc. (See Plate 88, Fig. 2.)

As a concession to artistic taste and perhaps conservatism, the parapet is finisht with a granit facing on the street side and a granit coping. One section of the finisht sidewalk is formed by a slab of reinforced concrete resting on the tops of the counterforts. (See Plate 89, Figs. 1 and 2.) The wall as seen from the rear is a series of vertical prism-shaped boxes which hold the earth filling (see Plate 90, Fig. 1), thereby not only retaining the roadways, but aiding, by the weight of the earth contained, to hold the wall in position. The width of the base is half the hight of the wall. Near the bottom of each pocket a 4-in. pipe opens thru the front slab, a trifle above the ground level, so as to afford proper drainage; and so far as possible, coarse material is used for the lower portion of the back filling. (See Plate 90, Fig. 2; Plate 91, Figs. 1 and 2; and Plate 92, Fig. 1.)

In all of the work to date, very great credit is due to two sets of people; first, to the City's engineers and their assistants, who have given to the subject so much of careful and intelligent study, working out every detail in advance of construction, so that the plans upon which contractors bid became the working plans, without essential change; and it must be remembered that 3 years ago when these plans were being prepared there was but little information in this country, in available shape, on the design of such walls, and practically no experience as to their behavior under load.

The others to whom credit is due, are the contractor's engineers and assistants, who, in a very intelligent way, have carried out the work in a time and labor-saving manner, well shown by an inspection of their shop and yards and the classification of materials, so that at a moment's notice any particular piece of timber or steel could be found; also in the method of assembling the materials, where judgment no less than skill has been required. (See Plate 92, Fig. 2.)

The following more technical description of the work may be of special interest to some; while the sketches, fotografs and the foregoing general description will probably suffice for others.

This detailed description is taken in large measure from a carefully prepared article in *The Engineering Record* of July 11, 1908, with some omissions therefrom and a few additions thereto:

All of the wall is of the same general type, having an L-shaped cross-section, with the base equal to about one-half of the hight.

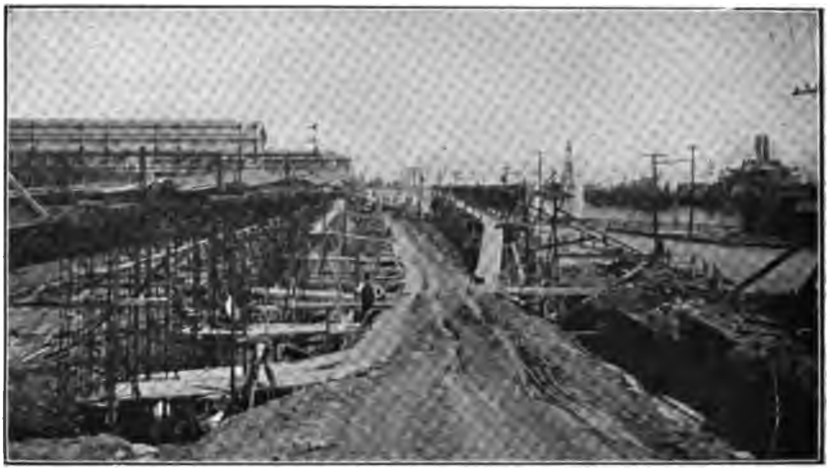

FIG. 1.—LOOKING FROM SOUTH STREET TO FERRY ENTRANCE.

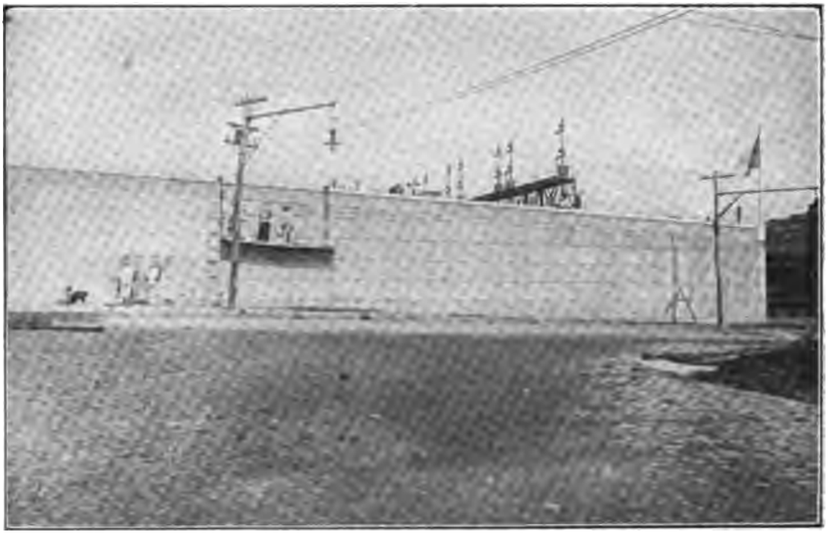

FIG. 2.—SOUTH STREET, EASTERLY WALL—POLISHING.

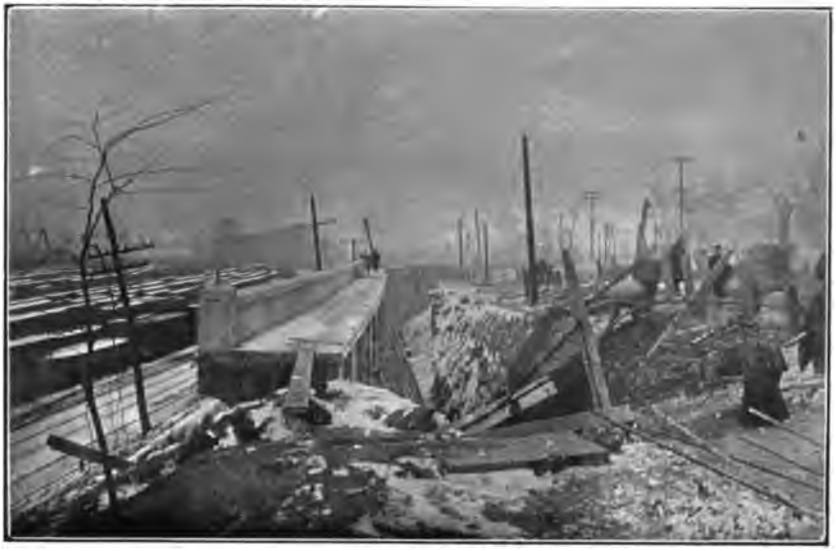

FIG. 1.—VIEW OF JAY STREET WALL, SHOWING PORTION OF SIDEWALK AS CARRIED ON THE RETAINING WALL.

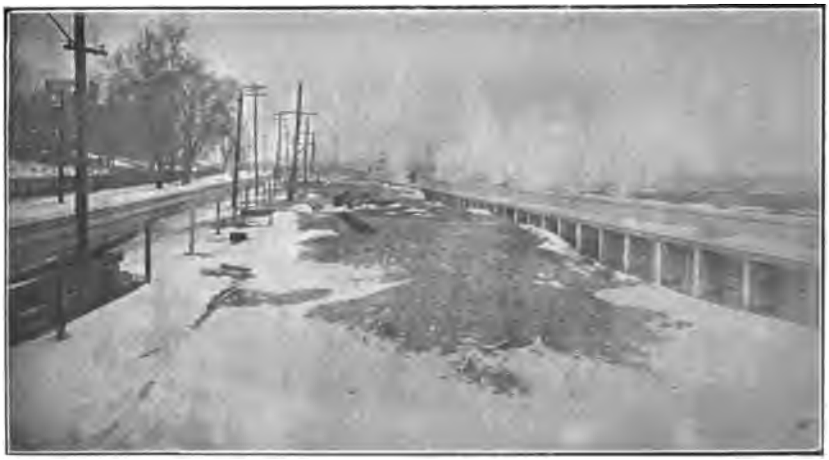

FIG. 2.—JAY STREET, READY FOR GRADING AND PAVEMENT CONTRACT.

The vertical portion is 12 in. thick at the top with a vertical rear surface and a front surface battered 1 in 48. It is reinforced by vertical and horizontal bars, 6 to 12 in. apart on centers, close to the outer face, and by vertical counterforts 12 and 15 in. thick and 8 ft. apart on centers. These are each reinforced by two complete sets of vertical and horizontal and diagonal bars, one set 3 in. each side of the center of the counterforts, as indicated in the elevations and details. The base of the wall projects uniformly 4 ft. beyond its vertical face, where it is finisht with a 45° fillet forming a massiv toe intended to increase stability and reduce the stresses. It is reinforced with upper and lower tiers of continuous horizontal longitudinal rods to which the lower ends of the vertical and inclined rods in the counterforts are hookt. The horizontal transverse rods in the counterforts are also hookt to the horizontal longitudinal rods in the main wall, and to the inclined rods in the rear edges of the counterfort, providing a very strong bond almost equivalent to trussing, in the reinforcement.

In some cases the upper part of the wall terminates in a simple parapet and in other cases it supports a double-cantilever reinforced-concrete sidewalk, forming a T-shape cross-section. The sidewalk concrete is 6 in. in minimum thickness, with an upper surface sloped 1 to 36, and finisht with 1 in. of granolithic. It is strengthened by curved and straight fillets, forming continuous corbels on the inner and outer faces of the wall, and by curved knee-braces or brackets 4 ft. 2 in. deep and 18 in. wide at counterfort points on the outer face of the wall. The brackets are lightly reinforced, and are integral with the top of the wall, the sidewalk and the parapet, thus making a monolithic structure of great strength. The inner face of the parapet is veneered with a vertical slab of cut granit 6 in. thick and dresst to careful bearing at the upper edge with the granit coping.

Where no sidewalk is provided on top of the retaining wall the construction of the coping and the granit face to the inside of the parapet is the same as above described, but the thickness of the top of the wall is increast 4 in. on the inner face to form a beveled shoulder just below the surface of the street, and provide bearing for the upper end of the counterfort, which tapers to a point. Cut granit pedestals 18 in. square and 3 ft. 3 in. in hight are located about 120 ft. apart in the parapet wall to form supports for ornamental lamp posts. They are provided with a 3 in. vertical hole in the center, thru which is run a curved 1-in. galvanized-iron condit pipe, capt and screwed at both ends, and having the horizontal portion embedded in the concrete of the bracket and counterfort to provide for the future installation of electric light wires.

All concrete, except for extra foundations, is made 1:2:5 with sand, or 1:4:5 with screenings in place of sand, and for large work is mixt with 1½ in. stone. For small work, moldings, and other special places, the 1½-in. stone is replaced by ¾-in. unscreened stone and all mortar faces are made with cement and screenings of stone from ¼-in. maximum size down to dust, free from dirt, in the proportion of 1:3. For all exposed surfaces of coves, brackets, moldings, and so forth, mortar not less than ¾ in. thick is placed against the forms with the 6-in. layers of concrete backing and thoroly puddled. No mortar facing is required for the main wall, but the concrete there is carefully spaded against the face of the form and within an hour after the removal of the latter it is ground to a smooth surface, and where necessary, washt with pure cement. Special pains are taken to secure high-grade steel in the reinforcement bars, which are required to have an elastic limit of 40 000 lbs., and an ultimate strength of 75 000 lbs. per sq. in., to elongate not less than 20% in 8 in., and to endure cold-bending tests. The principal quantities involved in this contract are 9 400 cu. yds. of concrete, 1 147 000 lbs. of reinforcement steel, 23 000 cu. yds. of excavation, and 40 000 lin. ft. of foundation piles.

Owing to the large amount of steel in the retaining wall, the great length of some of the bars, the requirements that the pieces should be single length unspliced rods and the necessity of maintaining them in exact alignment and position, the problem of construction became a difficult one, and was considered to involve heavy erection expenses. The contractors believed its satisfactory solution to be the key of the success of the whole work, and devoted very careful attention to it as a primary feature, about which other requirements and conditions could be arranged with more or less modification to suit the best method of handling the steel. It was evident that the great weight, length and number of bars and their somewhat complicated arrangement would involve costly and elabo-

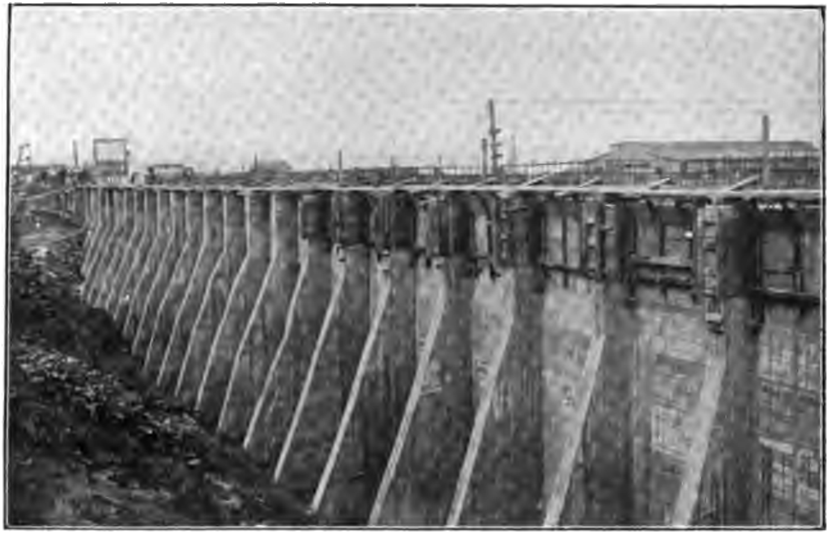

FIG. 1.—REAR VIEW OF JAY STREET WALL, SHOWING STEEL REINFORCEMENT FOR PARAPET.

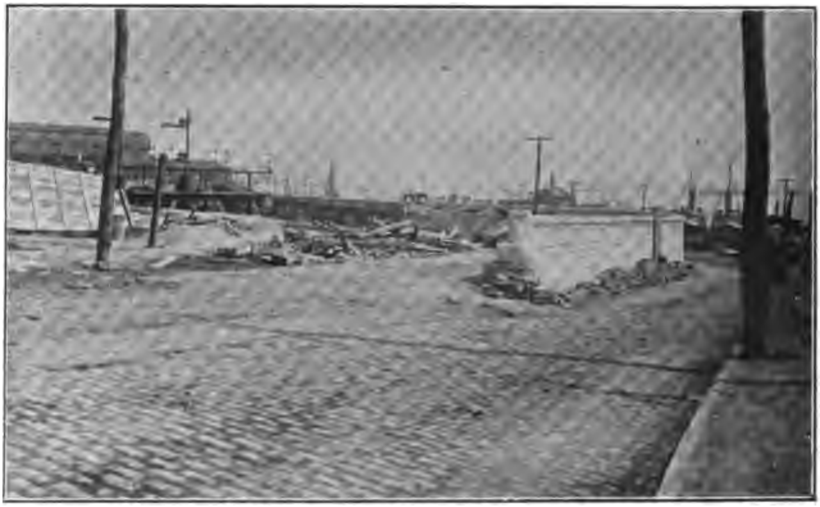

FIG. 2.—LOOKING TOWARDS FERRY. DIVIDING WALL BETWEEN FERRY APPROACH AND GENERAL DOCK APPROACH.

rate molds, falsework and bracing if the usual custom of spacing and supporting the steel from the molds was followed. It was therefore decided to make the steel independent and self-supporting, and to impose no other duty on the molds than that of retaining the wet concrete around the steel bars.

The type of bar, manufactured by the Expanded Metal and Corrugated Bar Company, was selected and approved, and preparations were made for ordering the 50 000 pieces required, of exact mill length, thus avoiding waste and cutting at the site. It soon appeared, however, that no economy would be derived by this plan on account of the probability of mistake and the great labor in sorting and maintaining the different lengths varying only by ½ to ¼ in. The bill of material was therefore made with all the bars grouped under order lengths varying by 3 in. from a minimum of about 3 ft. to a maximum of over 50 ft. Fortunately this order was made at a time and place where the mill could give it prompt attention, and the 600 tons of bars were rolled, shipped and received within about 45 days after the filing of the order.

The bars were delivered by lighters to the contractor, and were received in great confusion of size and length. They were carried a few hundred feet by wagons to a convenient stockyard adjacent to the work, and as fast as unloaded were sorted and placed in bins for each length plainly marked on a board at the end of every bin. This work cost about $1 per ton, but, having been done once for all, greatly facilitated the ease and rapidity of future operations, and has proved a very profitable investment.

The steel reinforcement bars are broadly divided into two classes, those in the vertical planes of the counterforts, and those in horizontal planes perpendicular to them. Supporting and securing the latter offered no difficulties, as they are readily located and fixt in the required position on the counterfort frame. The treatment of the counterfort bar was the difficult problem, which was simply and successfully met by the contractor's engineer, who determined to assemble and rigidly connect all of the bars for the counterforts in complete frameworks and erect them before the construction of the concrete forms, thus allowing the latter to be made with the simplest form of short sliding panels. The work has been carefully systematized, and the greatest economy of transportation, assembling and erection has been secured by cutting, bending, marking and bundling the bars at the storage yard, transporting each counterfort set as a unit and assembling and erecting it in the trench.

As the hight and bottom width of the walls vary with a constantly changing grade of the surface, no two counterforts are exactly alike, and the lengths of all of the bars often vary by increments of only ½ or ¼ in.

General drawings were provided showing the essential variation in the number and arrangement of the bars in the counterfort frames, and special small diagrams were prepared giving exact lengths and dimensions of all bent bars, and showing the hooks which are required at the ends of nearly all of the bars of each counterfort. Tag cards with wire fastenings were printed for every bar in the structure; these cards are of four distinctiv colors, white for the horizontal counterfort bars, green for the vertical counterfort bars, yellow for the inclined counterfort bars, and red for the transverse bars. Each card has five blank lines filled in at the drawing room with the counterfort number, diameter of the bar, the length of stock from which it is to be made, the designation of the sketch showing the type, and the governing dimensions of the bent or finisht bar. These cards are made up in sets, each set containing one card for every bar in the counterfort frame, and the sets are sent to the superintendent of the bending shop, who makes two series of bars for each set, corresponding to the two planes of reinforcement in each counterfort.

The cards are first delivered to the stockman, who selects each bar as required from the bin, and attaches the card to it and delivers it to the bending shop. At the bending shop the bars are cut to exact length and placed on a table in sets of 15 or 20, with one end inserted in a coke furnace where it is heated cherry red, withdrawn, moved a few feet transversely, placed on the bending table and the hook or intermediate bend quickly turned to exact dimensions. The bar is then moved transversely across the shop and the other end inserted in a second heating furnace, from which it is withdrawn and placed on a second bending table provided with a horizontal graduated scale 50 ft. long. A movable stop is set at the required point on this scale, and the bent end of the

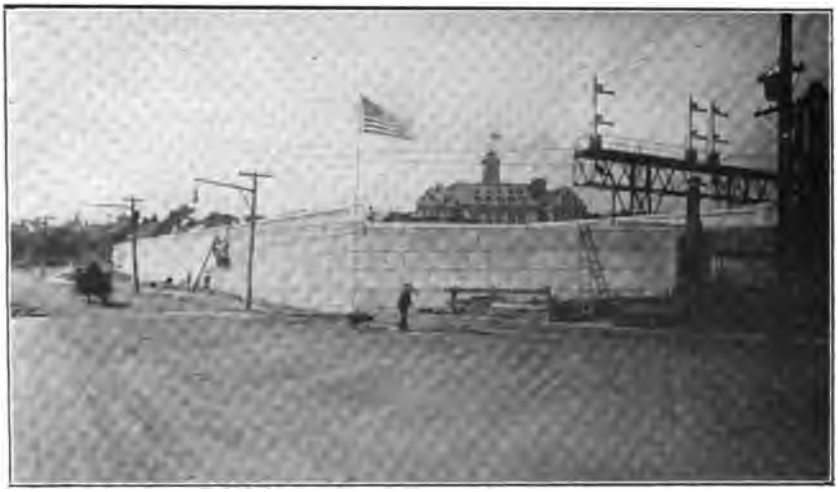

FIG. 1.—CROSS WALL AT BULKHEAD LINE. DOCK DEPARTMENT TO CONTINUE THE INCLINE TO THE FERRY GATES.

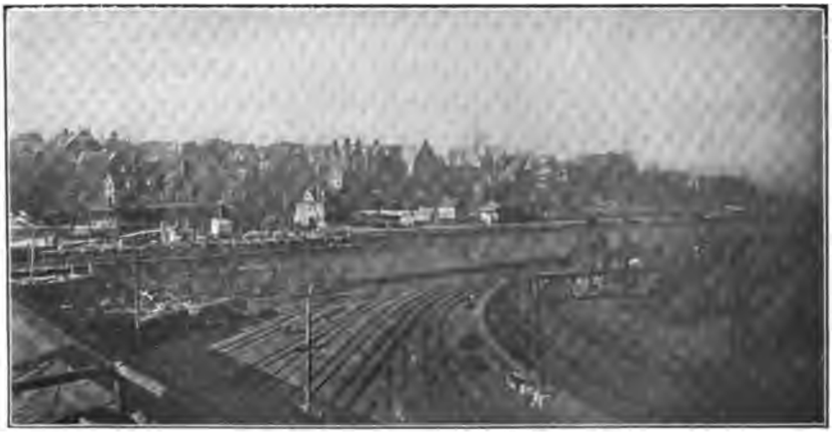

FIG. 2.—JAY STREET WALL. FERRY FOOT-BRIDGE TO RICHMOND TERRACE.

rod placed against it so that the heated end is in precisely the required relativ position for the second bend to be accurately made by the fixt bending mechanism. The finisht bars are taken from the table and all of those required for a given counterfort frame are bundled together and delivered in wagons to the foundation trench as required.

The rods are assembled in a horizontal plane in the bottom of the trench by the aid of the general diagrams, and all rods are securely wired together at intersection with short pieces of very soft annealed No. 16 gage wire, which is twisted tight and grips the corrugations so firmly that the two frames or sets of rods in each counterfort are always maintained at the uniform distance of 9 in. apart in the clear. A special device manufactured by the Universal Reinforcement System Company, was provided for separating and securing them, and has proved very successful. It consists of a short strip of 1 by ⅛ in. flat steel, notcht on opposit edges to receive staples of short, bent wire that are tightly secured by closing the notches with a single blow of the hammer.

Two duplicate frames for a counterfort having been assembled, one of them is blockt up 9 in. above the other in a horizontal plane, and the spacing pieces are inserted and the projecting wires twisted around the bars with which they are in contact, thus holding them very firmly and securely. The system of rods thus assembled forms a skeleton with abundant strength for its erection and maintenance, and it is easily revolved from a horizontal to a vertical position by means of a light tackle from the top of the last erected piece, or may be bodily set in position by a derrick when one is conveniently located for this purpose.

After the double frame is approximately located transversely, longitudinally and vertically, it is securely braced in position by some of the shorter pieces of reinforcement rods temporarily lasht to it in a horizontal longitudinal position, and others serving as longitudinal X-braces, which give it complete stability and virtually constitute a system of trussing which distributes stresses thruout the structure and keeps all portions of it in the required position. Final adjustment is secured by reference to the engineer's marks given on both sides of the trench and by measurement from horizontal arms projecting from the upper ends of vertical poles very accurately set in the line of the wall about 50 ft. apart. Both hights and alignments are determined by the position of the top and bottom longitudinal horizontal bars wired to the counterfort bars so accurately that none of the steel can become displaced more than ¼ in., and so strongly that it has an independent stability regardless of the forms and sufficient to enable it to dispense with all external bracing and guys, and even to sustain working scaffolds and concrete platforms which are extremely convenient and useful in the construction of the wall.

Considerable quantities of Giant Portland cement are stored in the office and warehouse bilding rented by the contractor, and sand and broken stone are kept in large piles on the surface of the ground. The various materials are delivered in wheelbarrows to Smith mixing machines of 1-yd. capacity. One of these machines is located near the dock, on a low tower with an inclined wheelbarrow approach, and delivers thru a small loading hopper provided with a segmental cut-off gate, operated by a lever, thru which Ransome dump carts are filled. The carts are pusht by hand along a wheeling platform between the two parallel walls and are diverted at different points on short transverse extensions to the face of the wall between counterforts. To reach the top of the wall these transverse platforms are somewhat steeply inclined in places and tackles are provided for pulling the carts up grade. For the other section of the wall, at the north end of the location, the mixing machine is located on top of the bank above the top of the wall and just below the surface of the road, and delivers thru a cut-off valve to a steeply-inclined chute, discharging into wheelbarrows on a runway alongside the wall.

Altho the rear faces of the counterforts are inclined, their molds are made full-length for about one-half the hight of the wall, where they are reduced and bilt up to the top with a second continuous length, the sloping rear surface being secured by placing an inclined edgepiece between the vertical faces and nailing it securely in position. As fast as each successiv vertical section of the wall is completed and set, the mold bolts are withdrawn and the molds moved upward one course, so that their lower edges just engage the finisht concrete and are kept in place by bolts and spacing blocks in the upper part and by the extension of the vertical cleats below the lower edges of the side boards.

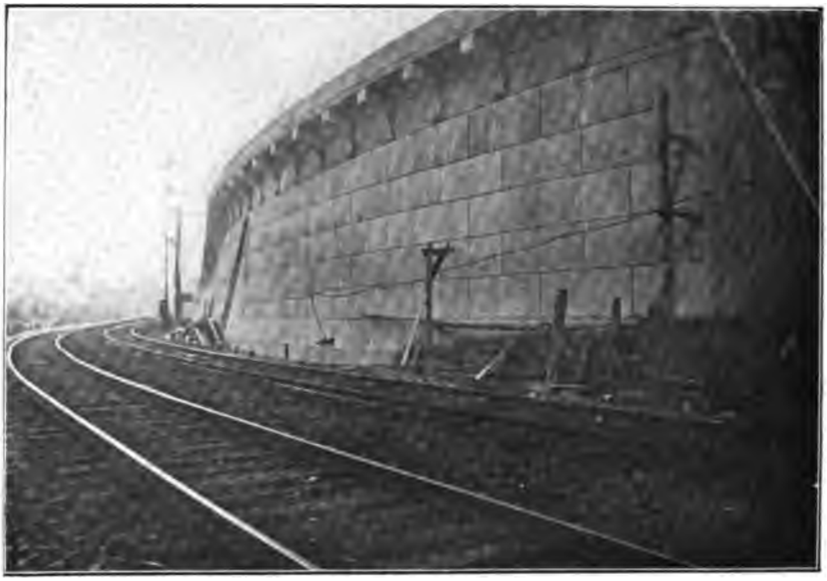

FIG. 1.—JAY STREET WALL. CURVE NEAR NORTH END, LOOKING TOWARDS FERRY.

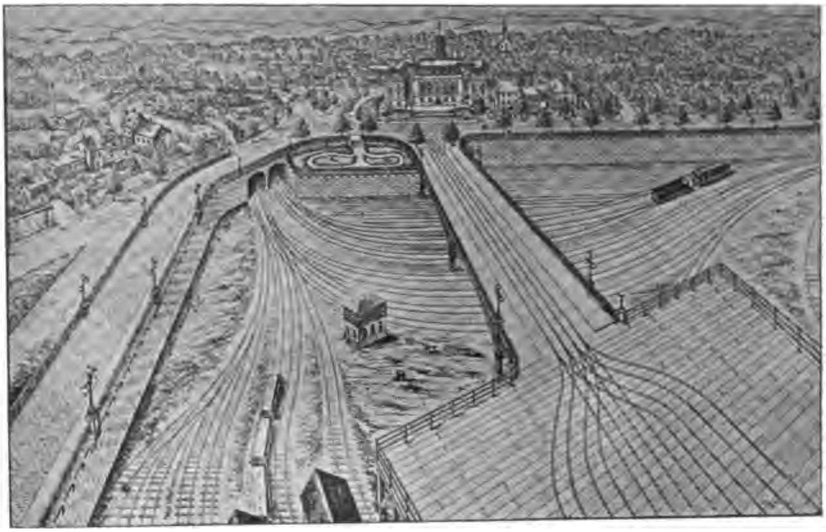

FIG. 2.—BIRD'S-EYE VIEW OF APPROACH TO FERRY HOUSE.

The upper edges of the mold for the counterfort serve admirably to support working platforms, and the whole system is very rapid, convenient and economical. Special molds are of course requisit for the cantilever sidewalk and fillets, and some difficulty has been experienced in satisfactorily securing them on account of their inclined position and the absence of vertical supports. This has, however, been successfully met by wiring them to the reinforcement bars, which are rigid enough to make this practicable. The curved surface of the cornice and brackets finishing the top of the wall on the exterior face are secured by the use of special galvanized iron molds in 7-ft. sections to correspond with the spacing of the counterforts.

It will probably be several years before the whole improvement is completed, but there will be nothing in the balance of the work differing materially from that described at this time; so it has been thought worth while to present the foregoing as a current matter of general and engineering interest.

We note the names of some of those who to date have been connected with this work, which, with the ferry terminal and its viaduct, the Boro Hall, the Public Library, and, we hope, a coming handsome Court House, will make of St. George one of the most beautiful portions of New York City.

CONNECTED WITH THE WORK.

For the City:

GEORGE CROMWELL, President of the Boro.
LOUIS L. TRIBUS, Commissioner of Public Works and Consulting Engineer.
THEODOR S. OXHOLM, Engineer of Construction.
GEORGE WOOD, Designing and Resident Engineer.
E. P. GOODRICH, Special Consultant as to Design.
HARRY W. WEINSTOCK, Transitman and Computer.
WM. H. HAEFNER, Transitman and Computer.
LOUIS RICHTER, Draftsman.

For the Contractor:

WM. A. ENGEMAN, Contractor.
GUSTAV KAUFMAN, Managing Engineer.
GEORGE SWITZER, Superintendent of Works.
GRANT S. TAYLOR, Assistant Engineer.

DISCUSSION.

Mr. Robert Ridgway.—I hope you have all heard Mr. Tribus' request for questions. I was struck with the showing of the fotografs of the wall, indicating the care with which every step of the work was done.

Mr. C. D. Thomas.—I would like to ask how the cost of that wall would compare with that of a concrete wall?

Mr. Tribus.—I don't remember exactly, but I think it was in the neighborhood of about 10% less than monolithic concrete.

Mr. Rudolph P. Miller.—The author describes this work as a steel wall, rather than one of reinforced concrete; that is, a steel frame encased in concrete. Do I understand that the concrete will not do any work in compression and that the steel will do all the work of the retaining wall?

Mr. Tribus.—Yes, practically all the work.

Mr. Miller.—The concrete takes compression also?

Mr. Tribus.—Most of the strain is tension in this form of design. Of course, there is some compression, but not a great deal.

Mr. Miller.—But the compression stresses are taken by the concrete, are they not?

Mr. Tribus.—Yes.

Mr. Ridgway.—Did you have any great trouble lining up the steel? Usually it is a work of considerable difficulty.

Mr. Tribus.—I think there was some trouble, but not any great difficulty. The men had good base lines to work from, so that with good instrumental work, and perfect harmony between the engineers and the contractor, the results desired were secured.

Mr. Miller.—The author has brought out a point that has been mentioned here at previous lectures on the subject of reinforced concrete, and that is, the desirability and value of the unit frame. The very fact that a unit frame is used makes it possible to get that lining of the steel work that is otherwise not obtained in the loose bar systems, and the author has given a very good illustration of unit frame construction. As explained, the steel frames are all planned beforehand, framed together and then put in place, very much in the same way that the ordinary steel construction is put together. The more successful constructions in reinforced concrete are those that are carried on along such lines. In the loose bar systems, it has been the speaker's experience, at least in bilding construction, that one cannot rely on the position of the reinforcing bars. It may be assumed that they are in place, but after the pouring of the concrete has begun it is impossible to know their exact location, whereas in the unit frame construction they are bound to hold their relativ, if not their exact positions.

Mr. Ridgway.—Do you use a metal skin for your forms?

Mr. Tribus.—For the coves and brackets, but not for the main faces.

Mr. Ridgway.—The treatment you give the face of the concrete afterwards, makes it, of course, somewhat unnecessary to be very careful with the form.

Mr. Tribus.—Somewhat unnecessary: but, at the same time, there was very great care used with the forms, so as to leave the least possible work after removal.

A Member.—There has been some objection to bilding retaining walls with counterforts, because they usually crack where the counterforts join the main portion of the wall. Have you experienced any difficulty in that respect?

Mr. Tribus.—We have had no serious cracks at all; a few small hair cracks, temperature shrinkage or whatever you might call them, but no cracks of importance have yet developt. Of course, they may come, as we don't feel assured that this wall is crack-proof.

Mr. Ridgway.—No provision was made for expansion joints?

Mr. Tribus.—No provision whatever, and to date nothing has been thrown out of line due to expansion or contraction.

A Member.—Does the contract specify the season of the year when the work shall be done?

Mr. Tribus.—We started the work in the winter and are ending it in the winter; the work was continuously carried on summer and winter. The contractor now is covering some of the work with boards and lines of steam piping, so that he may continue until completion.

A Member.—The contract did not specify any special season for the work?

Mr. Tribus.—No, not as long as proper safeguards were taken, but left it to our discretion.

A Member.—It is not so on the other side, in Europe, where the steel people do not work in the winter, only in the summer, especially in a wall of this kind; the temperature affects it very quickly and you may find cracks in portions of the wall.

Mr. Tribus.—It is possible.

Mr. Ridgway.—There is a theory among some concrete people, I believe, that if concrete is cast in the winter time it will not develop temperature cracks. Was any special precaution taken to make one day's work bond with another, or any attempt made to carry each section of the wall up from the base to the top in one operation?

Mr. Tribus.—No; just simply absolute cleanliness between the old and new work and making changes from day to day at lines of indicated joints.

Mr. Ridgway.—You noticed no sign of trouble?

Mr. Tribus.—None whatever.

A Member.—In what proportion was the concrete made? Were the faces straightened, or was it attempted to straighten them?

Mr. Tribus.—It was attempted to get the finer material as much as possible towards the face, so that there would be practically little of the aggregate to show when the work of cleaning was finisht. Outside of that there was very little attempt to do more than make sure that the material was thoroly settled. You could not do much tamping in the narrow compass with sets of steel rods coming right up in the face of the men doing the work, but the very fact that the walls are so thin made it possible to detect defects very quickly as the work was going on.

Mr. George W. Tillson.—I would like to inquire about these auxiliary ferries, of which the author spoke, whether they are to run up to St. George and connect, or whether they come directly to the City.

Mr. Tribus.—Come directly to the City; to the Battery. In all likelihood the East Shore Ferry will alternate, by going to South Brooklyn. That is one of the propositions, that one boat will leave Staten Iland, from Stapleton, and take in South Brooklyn on its way to the Battery, coming back straight to Stapleton; and the next boat go from Stapleton to the Battery and come back by way of 39th Street, South Brooklyn.

Mr. Tillson.—The object of that, then, is to take the traffic from the lower parts of the Iland and save the long haul for the teams?

Mr. Tribus.—That is it precisely; to save two miles on one side of the Iland and four miles on the other.

Mr. Tillson.—The grades, I understood, will not be over four per cent.?

Mr. Tribus.—Four per cent. will be the maximum grade and that for a distance of only a little over 500 ft.

Mr. Tillson.—I would like to ask the total estimated cost of the wall, when completed.

Mr. Tribus.—That for the wall, grading and pavements, everything necessary for the finisht work, was about $765,000.

Mr. Tillson.—What portion of that is paid by assessment?

Mr. Tribus.—Seventy per cent. to be taken by the City at large and thirty per cent. assesst over the whole Boro. Of course, the Boro as a whole actually takes a greater portion than thirty per cent., for it will share in the seventy per cent. assesst over the whole City.

Mr. Arthur S. Tuttle.—I would like to ask the speaker how this assessment list will be prepared, this thirty per cent. on the Boro and seventy per cent. on the City?

Mr. Tribus.—The speaker would be very glad to answer that question, but, in the form of asking, he will have to beg off from answering. There is one method available at present, making a full copy of Mr. Vogel's tax maps, and binding them up with a list of all the properties. The other method, to which I presume recourse will be had ultimately, will be an appeal to the Legislature for special consent to include this particular assessment on the general tax bills; a reasonable way of doing it.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Appendix to Paper No. 34.
(See Proceedings for 1907.)
PRESENTED NOVEMBER 25, 1908.

NEW INSTRUMENTS FOR PRIMARY TRAVERSE WORK.

BY MR. EDWARD H. HOLDEN,* MEMBER OF THE SOCIETY.

PRIMARY TRAVERSE WORK.

The relation of traverse work to triangulation is a most important one, and one often misunderstood. The idea that traverse work connecting triangulation can be of an indifferent quality, because the triangulation is precise, is erroneous.

It is absolutely essential that the traverse work shall be systematically uniform, if the determinations of the traverse stations are to have a true and consistent relation to the triangulation. The errors of the traverse which cause the adjustments necessary to conform to the triangulation must be of the same magnitude and of the same sign. Any theory contrary to this may be compared to that of a person in a railroad train establishing distances by the time of travel, with the train going at a varying rate of speed. For example, the measurement of the line connecting triangulation stations having an error of 0.5 ft. in one-half of the line, and no error in the other half, would result in an error of 0.25 ft. in the determination of the midway point. An error of +0.5 ft. in the first half and —0.5 ft. in the last half would result in a final error of 0.5 ft. at the midway point. So that the only safe procedure in this class of work is to employ the most accurate method whereby the error will be minimized and will approach equal magnitude and equal sign.

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* The instruments described in this appendix are the Line Clinometer and the Tape Stretcher. They are the invention of Mr. Holden, Assistant Engineer in charge of Surveys and Monumenting Topographical Bureau, Boro of the Bronx.—Ed.

In the Boro of The Bronx, the primary traverses, those connecting the triangulation stations, are made as accurately as possible, and nothing has been spared to secure this accuracy.

Certain mechanical devices have suggested themselves to take the place of stakes, the driving of stakes being an expensiv and a disadvantageous method, and, at times, prohibitiv. Portable tripods have generally taken the place of stakes, necessitating simultaneous levelling and a field force of from eight to ten men. By separating this force into two parties, the transit party for the observation of angles and the chaining party for the measurement of lines, decided advantages are derived. The transit party consists of three men and the chaining party consists of five, with a chief of party over all.

This separation of work suggested the application of a telescope to the portable tripod whereby the alignment and gradient of the tape lengths could be given, and the transit, level and rod eliminated from the chaining party, resulting in the above division.

TAPES.

The steel tapes used have a cross-section of ¼ of an inch by 1/50 of an inch, are generally one hundred and fifty feet long, and have only three graduated marks, one at the front end, one at the rear, and a third at the middle point. The tape is supported at each end, and in case of the 150-ft. tape, at the middle. Thermometers are attacht to the tape at each end, the metal back of the thermometer being in contact with the tape. The tape extends about three feet beyond the end graduations and terminates in loops which are put over the hooks of the tape stretchers. The tension applied is 15 kilograms (about 33 lbs.). The determination of tape lengths is made by direct contact, no plumb-bobs being used.

Invar tapes, made of an alloy of nickel and steel, have a coefficient of expansion extremely small, being one-thirtieth that of steel. They have a cross-section of one-quarter of an inch by one-fiftieth of an inch and are used in the same manner as steel tapes.

For Invar Tapes see U. S. C. & G. Survey Report for 1907, Appendix Number 4.

LINE-CLINOMETER.

This instrument is a portable tripod with a plunging level giving alignment and grade. (See Plate 93, Figs. 1 and 2.) It consists of a level (wye form) which rotates vertically around horizontal arms forming part of the level bar, an arc and vernier measuring the vertical angle. The connecting piece between the level bar and the levelling head is U shaped with the U resting on one side, thereby permitting the tape to come directly in alignment at an index post set in the lower part of the U. The index post carries at its side an eccentric cylinder which forms the support for the tape, the eccentricity allowing varying thickness of tape to have the upper surface at the same level with the index mark. The U-shaped piece rests on a sliding head, which, by a slow motion screw, moves forward and backward in the direction of the line. Below this is the ordinary levelling head with a shifting center. The tripod is an extension one with telescopic legs. Where greatest precision is desired, a transit right-angled off at one side sets the tripod vertically over the point in the ground. A plumb-bob is suspended from the instrument as in a transit, for use in setting up in line, and can be used in setting the instrument over the station, and also in determining the cut-off. A scale reading by a vernier to 0.0001 ft. measures the sliding motion. When the scale is set at zero, the index mark is at the center of the instrument, directly over the plumb-bob. The scale reads backwards and forwards from zero.

ADVANTAGES.

1. Separates the linear from the angular measurements, resulting in economy of time. The old method has the disadvantage that when the angles were being measured the chaining party was idle and *vice versa.*

2. Reduction of the field force from eight to five men.

3. Ease of adjustments of the level *versus* those of the transit for vertical angles and collimation.

4. Affords a check on the gradients, the vertical angle being observed by each instrument.

5. The observers, being responsible for the work, are most qualified to do the instrumental work, and do so at no expense of time.

PLATE 93.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
HOLDEN ON NEW INSTRUMENTS
FOR PRIMARY TRAVERSE WORK.

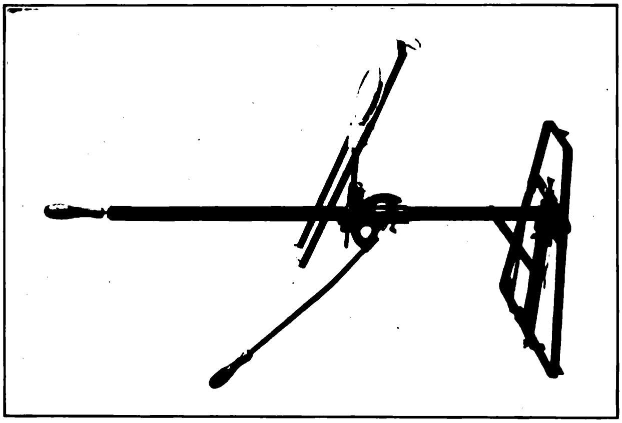

FIG. 3.—FRONT TAPE STRETCHER.

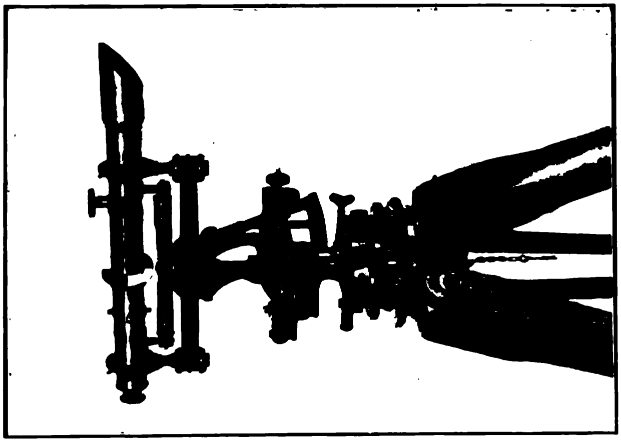

FIG. 2.—LINE CLINOMETER.

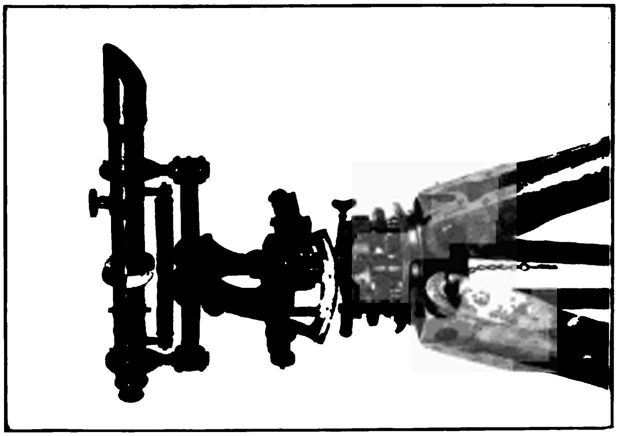

FIG. 1.—LINE CLINOMETER.

6. Eliminates the errors of plumb-bobs.

7. Avoids time and expense of driving stakes.

8. Can be used where stakes are prohibited, *e. g.*, in parks, pavements, etc.

TAPE STRETCHERS.

The front stretcher consists of an upright (a twin bar of iron) hinged sideways at its lower end on a foot base, and terminating at the top in a handle. (See Plate 93, Fig. 3.) On this upright, travelling up and down, is a block which supports the spring balance. The tension is applied by a half wheel, centered in the block, and workt by a lever attacht to its diameter. A strap connects the wheel motion to a rod which carries the spring balance. By means of the vertical motion of the block, the balance and front end of the tape are raised or lowered, while the hinge motion of the upright gives lateral motion for alignment. The rear stretcher is similar to the front stretcher, with the exception of the spring balance.

ADVANTAGES.

1. Ease of manipulation.

2. Absolute control, the tension being maintained constant for a longer time than with other forms.

3. With the tension released, it is self supporting, allowing the operator to quickly ward off an approaching interference, thus protecting the tape from injury. These stretchers can be used in standarizing tapes, and hold to 0.0001 ft.

FIELD PROCEDURE.

The measuring party consists of two observers, two tape stretchers and one recorder, who attends to the middle support.

Suppose the line A-B is to be measured. One of the Line-Clinometers, which we will call number 1, is set over the point A; the telescope is sighted to B and clampt horizontally; the rear stretcher is placed back of A and the rear graduation of the tape is brought to coincide with the index mark of the instrument. The front stretcher is placed ahead with a proper tension applied and the front graduation of the tape is brought in line by instrument number 1. Instrument number 2 is brought up to the front graduation, the tripod is made firm, and, by the shifting center, the index mark is brought approximately in contact with the front graduation of the tape. In the meantime, the center support, which is a staff one inch square, with a sliding target and a wire nail projecting for the tape support, is being placed by instrument number 1 in line and on the grade of the two telescopes. Observer No. 2, by the slow motion screw, brings the mark of the index post in contact with the front graduation of the tape. As he approaches this, he calls "ready," and when the rear calls "right," he makes the contact and calls "right;" Observer No. 1 has been watching his contact and instantly responds if the tape is steady; if not, he calls "steady" and the signals are repeated. Upon simultaneous signals of "right," each observer reads the thermometer and then the vertical angle. The tape is then carried forward, the rear man holding at Instrument No. 2, Instrument No. 1 going forward. The telescope of No. 2 is taken out of the wyes, reversed end for end, and sighted toward B. If not found on it, the slight movement to bring it on will not affect the position of the index mark. With ordinary working, the greatest movement would not exceed 2 in. in 150 ft. This extreme case would affect the mark 0.00002 ft., which is negligible. Instrument No. 2 gives the alignment for the second tape length, and the operation is repeated for the whole line.

Errors of line measurement are those due to (1) temperature, (2) tension, (3) grade and (4) contact or mechanical errors. By confining these to certain limits, the accuracy of the work becomes known. With the use of Invar tapes, the errors of temperature have been reduced from being the largest factor to one of the smallest.

The following table of error factors will illustrate:

INVAR TAPES.

(Coefficient of expansion 0.00000022.)

Classification of errors.	Maximum error per 150 tape length.	Error per mile.
Temperature	2° F.	.0026 feet.
Tension	1 oz.	.0042 feet.
Slope	20 seconds.	.0175 feet.
Mechanical	0.0002 feet.	.0070 feet.
Total		.0313 feet.

STEEL TAPES.

(Coefficient of expansion 0.0000065.)

Temperature	2° F.	.0682 feet.
Tension	1 oz.	.0042 feet.
Slope	20 seconds.	.0175 feet.
Mechanical	0.0002 feet.	.0070 feet.
Total		.0969 feet.

This table gives a fair idea of the comparativ values of the errors as applied to the foregoing field practis. I have not introduced the error of standardizing the tape lengths, as that is independent of the field errors and gives no values to the different field methods. The limits of error given are liberal. With Invar tapes and this measuring outfit, there is no reason why measurements should not be made with an error less than three-eighths of an inch per mile. Many precise measurements with steel tapes have been made in the Boro of The Bronx with errors less than 0.06 ft. per mile; many have been far below that. With Invar tapes, we expect to come within an error of 0.01 ft. per mile.

The greatest source of error in line measurements has been that due to temperature. By the introduction of Invar tapes with their small coefficient of expansion this source of error has been minimized. Disregarding, entirely, the temperature effects on the Invar tape, and standardizing at 65° F., and assuming a summer temperature of 100° F. and that of winter 30° F., no attention may be given to temperature corrections, and the work will be done with a maximum temperature error of one-half an inch per mile at either extreme summer heat or winter cold.

With the City Engineer's spring balance tape, and compensating for temperature, the error due to temperature will be between 2 and 4 inches per mile.

In other words, using an Invar tape and not correcting for temperature admits of an accuracy of from four to eight times that obtained by the use of a steel tape with its corrections applied. Applying temperature corrections to both Invar and steel tapes, the advantage of Invar over steel is between 16 to 1 and 32 to 1.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

ADDRESS OF MR. ROBERT RIDGWAY, PRESIDENT OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK, PRESENTED AT THE ANNUAL MEETING OF THE SOCIETY ON JANUARY 27TH, 1909.

In preparing the annual address required by the By-Laws reviewing the progress of engineering work in the City, and the work of the Society, I have followed the precedent establisht by my predecessors, and have first taken up the work of the Society.

We feel a just pride in the success the organization has achieved in the brief period of its existence. Our history shows that we have been true to our ideals. The spirit of co-operation between the various units of the City's engineering service, inspired and fostered by this Society, has, without dout, greatly increast the efficiency of that service. How greatly we, as individuals, have benefitted, personally and professionally, from our pleasant associations here, and the knowledge gained thereby, we can appreciate, but cannot measure.

When we first organized, a gentleman of considerable engineering prominence in the City remarkt that he would give the Society only three years to live. That period has long gone by and the end of each succeeding year finds us stronger in numbers and influence than at the beginning. We are now so firmly establisht that we can look confidently to the future, feeling assured that the influence of the Society for good, to ourselves and the great City we serve, will grow even more in the future than it has in the past.

Should this Society fail in its purpose after such a successful beginning, the result would, indeed, be a sad commentary on the professional spirit of the technical staff of the City. Such a failure is hard to conceive. If there is room for such an organization anywhere it is here in this large city, the engineering center of the world, where more than a thousand technical men in the employ of the municipality are engaged in working out a multitude of diverse and intricate engineering problems, the successful carrying out of which means so much to the material well-being of the community. Co-operation between the units of this force is absolutely essential if any weight is to be given to economy and efficiency. Surely a society should thrive here which aims "to elevate the standard of efficiency and harmonize the work of the engineering staffs of the various departments" of the municipality, and the need for such an organization is the reason for our being. So far as I am aware this is the only society of engineers organized with the above purposes in view. In this respect, therefore, we are unique. In no other city in the world, with the possible exception of our national capital, could such a society find the necessary support of numbers to secure its success.

The work of the Society is covered so fully in the annual reports of your Directors and of the various Committees, which have just been read to you, that I believe it is only necessary to touch on it briefly here, in spite of the fact that so much has been accomplisht. These interesting reports are commended to you for careful study. They can only indicate in a slight way, however, the earnest, faithful and efficient work done in your behalf by your Directors and by the several Committees and their Chairmen at the sacrifice of much personal convenience. Such service is in itself a most encouraging sign for the future success of our Society.

The success of the sixth annual dinner held at the Hotel Savoy on the evening of January 13th, is due to the hard and efficient work of the Chairman and members of the House Committee, backt by your cordial support. There were present 410 members and guests, a larger number than has been present at any of the preceding dinners. Among the guests were the Mayor and Controller of the City, and two of the Boro Presidents. The speeches made showed a recognition of the good work done by the Society, and an appreciation of its aims and purposes.

MEMBERSHIP.

The membership has grown since January 1st, 1908, from 507 to 595; 144 new members were elected, but the loss from resignations, deaths and other causes amounted to 56, leaving a net increase of 88, or 17 per cent. When we consider the financial conditions of the year, which resulted in the stoppage of much of the City's engineering work and the consequent reduction of the engineering staffs of some of its departments, the increase noted is on the whole encouraging. It is difficult to understand, however, why more of the large number of those eligible to do so, do not seek admission and take advantage of membership. In this connection I call attention to the excellent work accomplisht by the Auxiliary Membership Committee, appointed under a resolution of the Board of Direction, in the way of bringing the Society's aims and purposes to the attention of those who are eligible to join but who have not become identified with us. The work of this Committee has been so successful that it is suggested a similar committee be appointed during the coming year.

During the year the Society, and the engineering profession generally, has suffered a severe loss in the death of Mr. Othniel F. Nichols, one of our charter members and a former Vice-President. We miss the strength and encouragement of his presence with us, and we recall with a deep sense of gratitude his interest in the Society and his great service to us as an adviser and guide when we were organizing. That we have reacht our present position as a professional society is due, in a large measure, to his association and influence with us, and many of us feel his loss as that of a personal friend.

FINANCES.

On January 1st, 1909, the cash balance in the bank to the credit of the Society and in the hands of the Secretary was, after deducting liabilities, $1 060.46. On January 1st, 1908, the corresponding balance was $876.21. These amounts do not include the two New York City bonds of a face value of $2 000. The balance would have been larger but for the financial stringency that existed during the year, which, in spite of the energetic work of the business manager, had the effect of materially reducing the revenue from advertizements in the *Procedings,* making the latter rather a heavy charge against the Society, instead of a source of income. The necessary expenditures for the furnishing of our rooms, thereby adding largely to their usefulness, has also tended in the same direction. In view of the arrangements which have been made for the printing of the current volume of the *Procedings* without cost to the Society, and the fact that much of the furnishing of the rooms has now been done, it is believed that next year the financial conditions in these respects will be improved.

MEETINGS.

Of the eight papers presented at the regular meetings, other than the annual meeting, six were prepared and read by members, and the papers and discussions maintained the high standard of previous years. The current number of the *Procedings,* when publisht, should prove to be as valuable an addition to the engineer's library as any of the former volumes. The growing interest in the professional work of the organization was manifested by the increast average attendance at the meetings.

EXCURSIONS.

The several excursions to points of engineering interest about the City, under the guidance of the Inspections Committee, were pleasant features of the Society's activity during the year. These excursions worthily supplement the evening meetings, and give us an opportunity to see works that would ordinarily be inaccessible to us. It is a satisfaction to know that the attendance showed the members to be alive to the opportunities afforded them, and indicated an appreciation of the curtesies extended to the Society by those in charge of the works visited.

QUARTERS.

The Society is now well housed in the two comfortable rooms it has occupied for the past two years in this magnificent bilding, devoted to engineering organizations, and these quarters have been appropriately and attractivly furnisht under the direction of the House Committee and the Publication and Library Committee.

The large and valuable collection of engineering books which belonged to our late fellow member, Mr. Nichols, was added to the library in the early part of the year by the generosity of Mrs. Nichols, and a number of members have likewise indicated their interest in it by making many other important additions. While there has been an improvement in this respect, it is a matter of regret that full advantage is not taken by the members of their excellent library, and that they do not make more general use of their quarters. It is hoped, as time goes on, that they will come to regard the rooms more as their Society home and will make better use of them in consequence.

SPECIAL COMMITTEES.

Of the reports of special committees, that of the Committee on Unifying Datum Planes, read at the November meeting, is particularly deserving of notice. It recommended that a series of standard bench marks be establisht thruout the City by parties working under the authority of the Board of Estimate and Apportionment, referred to the datum plane of the United States Coast and Geodetic Survey, which is mean sea level at Sandy Hook. This recommendation has, by your direction, been forwarded to the Board of Estimate and Apportionment, and it is hoped will be acted on favorably. With such a chain of bench marks establisht, all working levels of the various departments can be connected with it. The correct relation between the zero of the Coast and Geodetic levels and the many datum planes now in use in the City will thus be correctly ascertained and become a matter of record, available for the use of those needing this information. Much of the confusion existing at present in the matter of grades and levels will thus be ended.

The government of modern large cities is still a new and frequently a vext problem; one with which our ancestors of a few generations back did not have to deal. Not so many years ago a city of a few hundred thousand inhabitants, altho a metropolitan center, constituted, generally speaking, a homogeneous community, sharing the same ideals, having the same habits and customs. In an old guide book in our library it is stated that in the year 1849 New York's population probably exceded 400 000, "making it among the commercial cities, the third in population, while it is second in commercial importance, being surpast only by London in the extent of its commerce." The same book, after describing some of the small parks of the city, states "there are other squares further up in the city, Madison, Hamilton, etc., which are extensiv but not yet laid out." This was only 60 years ago, shortly after the introduction of steam railroads, the telegraf and the Croton Water Supply, and before the many later inventions had revolutionized our manner of living. Contrast that with the present day metropolitan city of 4 000 000 inhabitants augmented each year by hundreds of thousands of new comers from all quarters of the globe, many of whom do not understand our language and have no conception of our traditions and institutions. It is stated that a million aliens landed at the Port of New York in 1907. With these rapid developments in mind, we have some conception of the great work in hand for those who are striving to solve the problem of making our representativ form of government successful under such trying conditions, and to bring the City's heterogeneous elements to a realization of their duties to one another in the interest of the general good. The municipal engineer can ill afford to neglect these considerations if he would keep pace with the times and not lag behind the rapidly changing and more complex requirements of the city. He must maintain an open mind on the needs of our cosmopolitan community and not allow traditional practis to hamper policies of municipal extension.

It is generally recognized that to provide for the increasing needs of the community, the material development of the City must not be neglected. If, for example, the docking and transportation facilities do not keep pace with the demands upon them, or if the water supply becomes inadequate, it is apparent to all that the City must stop growing until these matters are remedied. It is to the credit of our civic spirit, that a liberal policy in this respect has generally received popular support. We cannot safely assume that our supremacy as the metropolis of the western world will continue unless we make efforts to maintain it. These efforts mean large expenditures for public works of all descriptions and unless there is proper co-ordination of the work, waste must inevitably result. Our

Society, working within its sphere, has, I believe, done much to prevent such waste, and, if it does not neglect its opportunities, it is destined to do far more in this direction in the future. To this end, one of its chief aims, the harmonizing of the work of the engineering staffs of the several departments, should be kept constantly in the minds of the members.

In spite of the unsatisfactory financial situation which obtained generally in this section of our country during the past year and led to the shutting down of many municipal and other construction works, the magnitude of what was accomplisht in that period is so impressiv that I find it difficult to cover the subject in a comprehensiv way without burdening you with too many details.

As indicating the wealth of the City, the following table is of interest:

Assest valuation of taxable property for the year 1908	$7 158 190 400
Assest valuation of property exempt from taxation for the year 1908	1 239 883 798
Total	$8 398 074 198

The assessment of real estate is based on a system of permanent maps, which, at the end of the year 1908, cover the Boro of Manhattan, the Boro of the Bronx west of the Bronx River, and all of the Boro of Brooklyn, except Jamaica Bay and a small adjacent territory. In the remainder of the City the assessment is based on tentativ maps.

During the year the Board of Estimate and Apportionment authorized the following issues of corporate stock:

Topographical work in all boros	$218 000.00
Land for bridge approaches	2 000 000.00
Park improvements	784 783.00
Repaving in all boros	3 000 000.00
Improving the water supply, including care of sewage at Mt. Kisco	6 109 407.00
Aqueduct Commissioners	1 000 000.00
Board of Water Supply	33 600 000.00

High Pressure Fire Service...........	1 900 000.00
Changes in Rapid Transit Subway, including land required............	1 315 970.18
Public bildings, including fire and police stations...................	7 614 000.00
Museums and Libraries	815 000.00
School Bildings......................	8 773 629.00
Docks and waterfront improvements...	5 550 000.00
Bridges and viaducts.................	1 482 823.00
Gowanus Canal Improvement.........	170 000.00
Metropolitan Sewage Commission.....	80 000 00
Markets	45 000.00
Total........................	$74 458 612.18

The following improvements were also authorized by the Board:

STREET AND PARK OPENING PROCEDINGS.

Boro.	NUMBER OF STREETS AND PARKS AFFECTED.	NUMBER OF PROCEDINGS.	NUMBER OF STREETS AND PARKS AFFECTED.	NUMBER OF PROCEDINGS.
	1907.		1908, to Dec. 24th.	
Manhattan................	21	13	12	7
Brooklyn.................	39	35	128	66
The Bronx................	83	43	65	36
Queens....................	57	32	16	13
Richmond	4	3	3	3
Total..................	204	126	224	125

SURFACE IMPROVEMENTS.

Boro.	TOTAL, 1907.		1908, to Dec. 24th.	
	No.	Amount.	No.	Amount.
Manhattan	19	$198 500	16	$175 700
Brooklyn	159	1 372 700	90	792 000
The Bronx................	77	2 337 800	19	560 500
Queens....................	29	514 900	14	179 300
Richmond	16	53 700	..	....
Total..................	300	$4 477 600	139	$1 707 500

SEWER IMPROVEMENTS.

Boro.	TOTAL, 1907.		1908, to Dec. 24th.	
	No.	Amount.	No.	Amount.
Manhattan................	19	$162 500	15	$83 200
Brooklyn................	111	809 300	91	696 800
The Bronx................	49	1 154 400	36	364 000
Queens................	29	129 400	20	91 600
Richmond................	14	283 350	6	81 600
Total................	222	$2 538 960	170	$1 315 100

TOTAL PHYSICAL IMPROVEMENTS.

Boro.	TOTAL, 1907.		1908, to Dec. 24th.	
	No.	Amount.	No.	Amount.
Manhattan................	38	$361 000	31	*$857 900
Brooklyn................	270	2 182 000	181	†1 488 300
The Bronx................	126	3 492 200	55	‡324 500
Queens................	58	644 300	34	§270 900
Richmond................	30	337 050	8	‖81 000
Total................	522	$7 016 550	309	¶$3 022 600

* Resolutions aggregating $106 748.25 rescinded but not deducted.
† " " 443 900.00 " " " "
‡ " " 12 700.00 " " " "
§ " " 7 800.00 " " " "
‖ " " 9 280.00 " " " "
¶ " " $580 428.25 " " " "

The amount authorized for physical improvements in 1907 compared with that for 1908 shows the effect of the financial conditions of the past year, the amount for 1908 being less than one-half that for the former year.

BOARD OF WATER SUPPLY.

GENERAL.

An ample supply of good water is so essential to the comfort and health of a great city that the very existence of the latter may be said to depend upon it. The problem is one of more than usual complexity in the case of New York, bounded as it is on three sides by the sea, and by the states of Connecticut and New Jersey, preventing the development of any supply in their directions. The water must, therefore, come from the north, and as the nearest water shed of any size, the Croton with its 360.4 square miles, will have been developt practically to its safe capacity with the completion of the present works, the increase needed would naturally come from the streams of Putnam and Dutchess Counties immediately to the north. The Legislature in its wisdom has seen fit, however, to forbid the City's use of these streams, leaving the Catskill Mountains as the nearest available source for the increast supply. The Hudson River, 80 miles or more above the City, might be used, thereby saving some length of aqueduct, but this would require pumping the supply to a hight of 400 ft. above tide, and thoroly filtering it, because the river acts as a sewer for the many cities and villages on its banks. Enormous storage reservoirs would also have to be constructed in the Adirondacks to maintain the flow of fresh water in the river above the amount to be pumpt, otherwise the salt water would be drawn into the supply. It is interesting to note here that during the drouth of last autumn water drawn from the taps in Poughkeepsie, which obtains its supply from the Hudson River, 75 miles above New York, was found to contain over 300 parts of chlorine to the million, the water having, at times, a distinct salty taste. These considerations make the cost of obtaining a Hudson River supply much more expensiv than one from the Catskills. Added to this is the objection, sentimental or otherwise, to using water from such a contaminated source as the Hudson River, when the water from Catskill streams, renowned for its purity and general excellence, can be obtained.

The question is frequently askt, even by engineers, why the City does not go to Lake George or Lake Champlain for its water, forgetting that the elevation of the latter is so low that the supply would have to be pumpt, while the watershed of Lake George is so small as to be only capable of furnishing an amount much smaller than is now obtained from the Croton; furthermore, a much longer aqueduct would be required for either development than for the Catskill water, making the cost practically prohibitiv at this time.

Those who had the opportunity last fall to observe the conditions of the streams and reservoirs, not only in the Croton watershed, but thruout this whole section of the country, were imprest with the fact that work for the increast supply was not begun too soon, and in fact had been too long delayed. Starting in the spring of 1908 with every reservoir in the Croton basin full to overflowing, due to the extremely heavy rainfall of the preceding six months, the drouth of the summer and fall saw them so far depleted that but 40 000 million gallons remained of the total of 87 000 million gallons in storage. Springs and streams which were believed to be never-failing, became dry, and in many instances inconvenience and suffering resulted, especially in some of the small towns and villages which had relied on the flow of the streams for their water supplies. In some villages water from wells and springs was peddled thru the streets at a cost to the consumers many times higher than is paid for it here. During this period New York felt no inconvenience, thanks to the wisdom and foresight of those, who in years past provided for such a contingency, against the protest of a strong opposition which urged with plausibility, the resort to temporary expedients for relief. The same arguments are urged in opposition to the proposed development today, and should they prevail, disaster will surely result. Starting now with the Croton reservoirs less than half full, the conditions in the City are likely to become serious before the close of the present year, unless the rainfall is materially greater than for the last five months of 1908.

It may be askt, why with water going to waste over Croton Dam a year ago, it is not wise to conserve it by constructing other reservoirs in that watershed. It is answered that this waste was the result of a precipitation during the twelve months ending May 31, 1908, that was exceded but once in the Croton watershed during the past forty-one calendar years, and then by only $\frac{5}{8}$ in. Thirty-one inches of this rainfall was concentrated in the last four months of 1907, exceding by 18% the fall for any four consecutiv months of which we have record. Had the works now under construction at Croton Falls and in contemplation been completed, some of this waste would have been prevented. To save the remainder would require the construction of large reservoirs at great cost, which might be filled but once in forty years, if then. As the resulting cost per million gallons would excede the rate for the Catskill supply, such a policy would be hard to justify. It is well to note here that the precipitation for the last six months of 1908 was only 16.38 in.

The Catskill supply contemplates the eventual development of the watersheds of four Catskill Mountain streams; the Esopus, the Rondout, the Schoharie and the Catskill Creeks, which have a combined available drainage area of about 750 square miles. The supply from them, added to that proposed to be obtained from Suffolk County and to the supply from such of the present sources as will continue useful, will furnish New York with nearly 1 500 million gallons daily, sufficient for a population of at least eight million.

Present work in the Catskills is confined to the Esopus Creek with a catchment area above the point of diversion of about 250 square miles, which will give at least 250 million gallons daily. As a matter of fact the average flow for the past two years by actual gagings was over 370 million gallons daily. In this connection it is interesting to note that the Board of Water Supply maintains rainfall and stream-gaging stations over the entire Catskill district and is accumulating data valuable, not only for water supply purposes, but in claims for damages for diversions.

The topography of the Esopus watershed is favorable for a very large reservoir at the lower end of the area, and the relations of the several Catskill drainage areas make it advantageous to construct the Ashokan Reservoir on the Esopus large enough to furnish all the storage for that stream, and a very large part of that needed for the Schoharie Creek as well. The Ashokan Reservoir, as now being bilt, will have a capacity of 127 billion gallons. It will be 12 miles long, somewhat over a mile wide and will have a surface area of about 8 000 acres, with an average depth from 50 to 60 ft. About 15 000 acres of land will be acquired for it, which provides for a marginal protectiv strip about 1 000 ft. wide around the basin. The exterior line of the City's taking will be defined by a highway 34 miles long, which is to be substituted for the roads in the flooded areas.

The Catskill Aqueduct, leaving the Ashokan Reservoir at an elevation a little over 500 ft. above tide, will deliver the water into the Hill View distributing reservoir near the City line, at elevation 295. It would, therefore, be possible to carry the supply into Manhattan under such a head that it would rise to a height of 250 ft., thus overtopping a twenty-story bilding. The present Croton gravity supply is not available more than 80 ft. above tide.

No relief can be expected from Catskill sources before the year 1913, and the first relief will come to Manhattan and the Bronx. Meanwhile it was early recognized that other measures would be necessary to permanently relieve Brooklyn and Queens of their chronic water shortages. The Board, therefore, in October, 1906, assigned a force to make exhaustiv surveys and studies of the Suffolk County sources, with a view to utilizing the large quantity of excellent water there, which is now being absorbed by the underlying sands and wasted by seepage into the sea. This work was prosecuted vigorously and a plan evolved from the data collected, which formed the basis of the City's petition of July 29th, 1908, to the State Water Supply Commission for permission to use this water. Several hearings have been held and the Commission is now considering the briefs submitted by the supporters and opponents of the petition. The approval of the Commission is required before the Board can proceed to acquire land for and construct the necessary works.

The results of the studies mentioned have been extremely interesting. Owing to the increasing transit facilities, the population of the Long Iland boros is growing rapidly. The population of Brooklyn at the beginning of 1908 was probably 1 470 000, and its average daily water consumption increases about eight million gallons each year. When all of the available ground water of Nassau County is tapt, completing the development of the Ridgewood sources, the total safe yield will not be sufficient to provide for such a series of dry years as existed in 1895 and 1896; consequently the need for action is urgent. The depth and extent of the most promising of the underground storage of Suffolk County were determined by sinking test wells, and the plan evolved provides for collecting works capable of gradual increase to an ultimate yield of 250 million gallons daily. The area from which the water will be collected is about 8 miles wide and 40 miles long, extending from the Nassau-Suffolk county line eastward nearly to Great Peconic Bay. This includes the southern Suffolk sources of 294 square miles, and the Peconic Valley sources of 38 square miles, a total of 332 square miles.

The trunk aqueduct, about 50 miles long, will be about 3 miles north of and approximately parallel to Great South Bay. Four tributary aqueducts will lead into it from the north at intervals of about 8 miles, the most westerly one being east of the Suffolk County line.

The water will be collected by pumping from deep wells into the distributing system, the wells being spaced about 1 000 ft. apart on a right-of-way to be secured. The latter is to be made 1 000 ft. wide, so as to protect the wells from pollution and the encroachment of dwellings. Studies indicate that the pumps may be run by electric motors, operated from sub-stations, which in turn will derive their power from a central plant, located at tide water on Great South Bay. Four infiltration basins on Carlls River, Connetquot River, Patchogue Creek and Carmans River, will collect the ground waters resulting from flood flows and retain them in the natural sand beds for use when the levels of deep wells in other localities are lowered by extended drouths.

The aqueduct is to be constructed of concrete of the same type as the Catskill cut-and-cover aqueduct, proportioned in the case of the trunk line from an initial 25 million gallons daily capacity to a 250 million gallons daily capacity at the City line. The branch aqueduct from the Peconic basin will be 10 miles long and the other three branches each about 8 miles along. Thru Nassau County and the Boro of Brooklyn the aqueduct will parallel the present Ridgewood condits a distance of 25 miles to the vicinity of the existing Ridgewood pumping station, where a new pumping station will be required. To relieve immediate necessities a portion of the new supply can be delivered directly into the existing 72-in steel pipe line of the present system, which, for the purpose, would have to be extended 14 miles east to Massapequa.

As there might be some danger of the water becoming hard and brackish, due to the admixture of salt water by infiltration to the wells along the south shore, it is planned to meet this by bilding low earth dams across the mouths of the estuaries, thus forming a series of small fresh water ponds at a slight elevation above sea level, which will crowd out the salt water.

PROGRESS.

Notwithstanding the business depression of the year, which affected all municipal enterprises, a great advance was made in the work of the Board, but the progress naturally fell short of what it would have been had the work been unhampered by this consideration. As before stated, the Board of Estimate and Apportionment authorized issue of corporate stock for the use of the Board, to the amount of $33 600 000, making, with the amount previously authorized, a total of $60 202 000 for this work.

Practically all of this amount is to cover large contracts, many of which have not been let. Most of them will have from three to seven years to run, so that the expenditures on their account will cover a long period. To date contracts of an estimated value of $26 423 502 have been let on account of permanent construction, and the work done under them to December 31st, 1908, amounted to $2 014 624. As is generally known the estimated cost of developing the supply from Catskill sources is $162 000 000, but this amount does not include all of the distribution work, and, of course, nothing for the development of the Long Iland supply.

The progress made during the year is summarized as follows:

HEADQUARTERS DEPARTMENT.

This department is charged, among other duties, with the general designs for the work and the preparation of contracts. Of the 92 miles of main Catskill Aqueduct, contracts were prepared in previous years for 10.7 miles and this year for 23.8 miles in this department, and in addition, contracts for 18.2 miles more were prepared in the field offices, making 52.7 miles, or 57% to date. The accompanying contract drawings, as well as many special designs, were made, and many studies of important features of the work were undertaken. Of the most interesting studies were the following methods of aerating water upon its issue from the Ashokan and Kensico reservoirs for the purpose of removing the objectional odor and taste, (1) fall in cascades, (2) forcing air thru it, and (3) its issue thru jets and nozzles. Of the last mentioned various types were tested in practis. The structures planned and designed for the aqueduct head works make provision for generating power for lighting and for operating the gates; they also provide for an aeration pool of the full aqueduct capacity, a screen chamber and a concrete Venturi meter, capable of measuring the entire flow of the aqueduct and bilt integrally with it.

The design of pipe siphons was continued. The experimental section of reinforced concrete pipe, 11 ft. in diameter and 210 ft. long, at Hunter's Brook, was tested at a working pressure of 53 lb. per sq. in., for which it had been designed. It was concluded that the use of this type for such pressure was feasible, but offered no advantage of economy, and study upon it was discontinued. Investigations were then concentrated upon steel pipe and protection of the metal formed the subject of study and experiment. Asphaltic and related coatings were discarded for an inner lining of cement mortar and an outer masonry covering, which had formed the subject of exhaustiv tests.

Special investigations were made on possible emergency supplies from Fishkill and Peekskill Creeks and also from the Hudson River at Storm King. One of the most important studies was a comprehensiv one for the distribution of the new supply, leading to the conclusion to carry the main supply thru the Bronx and Manhattan to Brooklyn in a deep rock "pressure" tunnel, similar to the one now in service for the Croton Aqueduct under the Harlem River, and to those designed for carrying the Catskill Aqueduct under some of the deep valleys. The location of such a tunnel is affected by the requirements of the delivery of water, by the street and park systems and by geologic conditions. Tentativ locations for the tunnels, traversing areas of maximum consumptions, modified by the economic necessity of keeping under streets and parks, were laid out. Borings are being made along the lines, under a contract, to determin what modifications, if any, are advisable and what conditions will be met in tunneling.

The feasibility of delivering a high level gravity supply from portions of the Croton shed and the cost of enlarging the capacity of the Catskill Aqueduct below Croton Lake for this purpose, were investigated.

RESERVOIR DEPARTMENT.

This department has supervision of the development of the four Catskill watersheds. As before stated work is concentrated at present on the Esopus shed, where the construction work, begun in 1907, has been vigorously prosecuted. Work on the main dams for the reservoir has been in progress thruout the year. These dams consist of a series of dams and dikes about 4 miles long and involve the handling of about one million cubic yards of excavation, 7 million cubic yards of embankment and 900 000 cu. yd. of masonry, the contract having an estimated value of $12 600 000. Camps to house some 1 600 laborers were bilt, a large amount of plant installed, the foundations of the dam in the bed of Esopus Creek advanced beyond reach of interference from ordinary flows, and progress was made at other vital points. All told, about 7% of the contract was completed during the first year.

All the land surveys are finisht and the condemnation procedings, which have been in progress on some 8 282 acres of land, needed for the early construction of the dams, are well advanced. A Committee of the Board of Estimate and Apportionment is negotiating with the Ulster and Delaware Railroad looking to the removal of that railroad from its present location within the basin.

NORTHERN AQUEDUCT DEPARTMENT.

This department includes the 60 miles of Catskill Aqueduct between the Ashokan Reservoir and the Croton watershed. Of this, including 10.7 miles let in 1907, 26.1 miles is under contract, representing a cost of $13 720 013. Work to the value of $974 553 was accomplisht during the year, making, with the $150 964 of the preceding year, a total of $1 125 517. The entire line of the aqueduct is definitly located and the real estate maps for the right-of-way prepared. Property for the latter has been acquired for 41 miles, aggregating 1 166 acres.

The most interesting contract under way is that for the so-called pressure tunnel, 14½ ft. in diameter and 4½ miles long, to carry the aqueduct under the Rondout Valley, known as Contract 12. This requires eight shafts averaging 553 ft. in depth, the deepest one being 733 ft. The tunnel will be about 700 ft. below the hydraulic gradient and over 400 ft. below the ground water level of the valley. For these reasons and because of the complex geologic structure of the rock underlying the valley, this siphon is regarded by the writer as the most interesting single feature of the work of the Board, and far more difficult of execution than the proposed tunnel under the Hudson River. No less than eight formations of rock are penetrated by the shafts and tunnel, ranging from soft shales to the hardest kind of quartzite, and many of the rocks are badly folded and faulted. The contractor was ordered to procede with the work on June 16th, and has made such rapid progress that at the end of the year the eight shafts had been excavated to a total depth of 1 901 ft., ranging from 134 ft. to 311 ft. in depth.

Some concrete aqueduct was constructed back of Peekskill of the standard 17 ft. by 17½ ft. horse shoe section, and about one-half a mile of tunnel was driven in the Hudson River highlands to the northeast of Peekskill, but the progress in this vicinity has not been as good as was expected.

The two shafts on the shores of the Hudson River at Storm King, where it is intended to cross with the aqueduct, have been sunk about 250 ft. below tide level, and preparations are being made to carry them much deeper with a view to driving the tunnel beneath the river in sound rock well below the rock bottom of the gorge. The latter has not been thoroly explored yet, the work of boring from scows in the channel in connection with it having been badly hampered by the loss of several of the deepest borings, they having been run down by the long tows which navigate the river.

SOUTHERN AQUEDUCT DEPARTMENT.

In addition to the supervision of the aqueduct from the Croton watershed to the distributing reservoir at Hill View, Yonkers, this department also has charge of that reservoir as well as the great Kensico storage reservoir. The latter is calculated to impound 40 000 million gallons, or over two months' supply, for reserve use when the aqueduct above it may be out of commission for cleaning or repairs. This reservoir is to be formed by constructing a large dam across the Bronx River, raising the present Kensico Reservoir 110 ft. A location for the dam has been selected upstream from the present structure, and this will require, during construction, the drainage of Kensico Lake. Temporary arrangements are being made for continuing the present supply from this source while the new works are in progress. Much study has been given to the architectural and landscape treatment of this dam and its setting, for the purpose of making it a pleasing structure. This consideration is of more than ordinary importance because of the growth of the City in that direction, which makes it probable that the area reserved about the reservoir will eventually form part of the City's park system.

The location of the proposed filter beds having been fixt near East View, and it having been decided to postpone their construction for some years, the aqueduct has been so located as to bypass them. This secures an economic location for the aqueduct and avoids possible future interference with the construction of the filtration plant, the latter being the largest ever planned.

The diversified country which the aqueduct must necessarily traverse in this department has made the problem of location a very difficult but interesting one, and has required extensiv exploration work. The variety in the type of construction which consequently results will add to the interest of the engineers who will have the supervision of it.

For convenience of administration the department is divided geographically into the Croton, Kensico, White Plains and Hill View divisions, their names indicating the location of the work they cover. In addition there is an Executiv division at the department office. The latter has prepared the contract, specifications and drawings for two large aqueduct contracts and a third one is nearly ready; this in addition to the preparation of the final real estate plans covering the aqueduct right-of-way from the north end of the department to Kensico reservoir, and numerous studies, designs and plans.

A description in detail of what has been accomplisht in the field would require more time than is permitted here, but a few figures will convey some idea of the great amount of work done. One hundred and eighty-two deeds were abstracted; 148 properties, covering 5 483 acres, were surveyed; 6 092 acres were mapt; 442 rod soundings, aggregating a depth of 3 355 ft., were made; 157 testpits, with an aggregate depth of 1 368 ft., were dug; 94 core borings, with a total depth of 7 152 ft., and 252 wash borings, with an aggregate depth of 4 106 ft., were made. In addition many pumping tests were made in core-boring holes on the north and south sides of Croton Lake to determin the tightness of the rock thru which it is proposed to drive the deep siphon tunnel under the lake. Studies were made of methods of construction and the availability of construction materials for the East View filters.

The title to 1 133 acres of land is vested in the City to date.

LONG ILAND DEPARTMENT.

Topographical surveys along the line of the aqueducts from Brooklyn to the eastern part of Suffolk County, continued from the preceding year, were completed, and monuments were set to mark the primary and secondary triangulation stations controlling these surveys. The definit location of the aqueduct was made from Brooklyn to Great River in Suffolk County, a distance of about 40 miles. The real estate surveys were well advanced at the end of the year. Rainfall observations, stream gagings and ground water measurements, begun in 1906, were continued.

AQUEDUCT COMMISSIONERS.

The Croton Dam having been completed in 1906, the water was permitted to rise behind it. The reservoir was filled to overflowing, water running to waste over the two feet of flashboards on the spillway from November 6th, 1907, to June 8th, 1908, to the amount of 79 234 million gallons, this result being due to the very heavy rainfall of the last seven months of 1907 and the first five months of 1908, before mentioned. The dam was thoroly tested by this flooding of the reservoir with gratifying results, only a very slight seepage appearing on the outer surface. Such results reflect the highest credit on the engineers who designed and bilt this great structure, and were anticipated by those who were familiar with the great care taken in all steps of the work.

The Cross River Reservoir can be considered complete with the exception of a small number of improvements, principally to the grounds below the dam. It was completely filled during the year, thus adding 10 000 million gallons of water to the storage on the Croton watershed, or about one month's supply for Manhattan and the Bronx at the present rate of consumption.

Work on the Croton Falls Reservoir was vigorously continued and excellent progress made. Over 60% of the work under contract is now completed, costing to date more than $1 950 000. One million cubic yards of earth and 165 000 cu. yd. of rock have been excavated, and 100 000 cu. yd. of cyclopean masonry laid. During October 24 266 cu. yd. of cyclopean masonry and 1 578 cu. yd. of concrete facing blocks were placed in the dam, this being a record-breaking rate for an eight-hour day, and the maximum laid in any month.

Preliminary surveys, plans and estimates have been made for a proposed reservoir on the east branch of the Croton River near Patterson, calculated to impound 20 000 million gallons at a cost of $3 250 000.

Plans were prepared for installing gates and gate machinery, headhouses, screen chambers and blow-offs at points along the line of the new aqueduct, where they have been found necessary for the proper handling of the water.

At the Jerome Park Reservoir a contract has been prepared and is about to be given out for the bilding of an iron fence around the completed westerly reservoir to protect the works and guard the water from pollution, and for a temporary fence around the incomplete easterly reservoir, pending a decision on the question of establishing a filtration plant and storage in this basin.

DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY.

Manhattan and Bronx.

The supply of water on storage in the Croton watershed has gone from one extreme to the other. In the early part of the year all the reservoirs were full with over 87 000 million gallons on hand, and water wasting over the spillway of New Croton Dam. At the end of the year, after several months of unusual dryness, there were but 40 000 million gallons in storage. The average daily consumption in the two boros was 327 million gallons, of which 307 million came from the Croton basin.

The plans for a sewage disposal plant at Mt. Kisco in the Croton watershed are completed and ready to advertize as soon as the work of laying the sewers, which is being done by the village itself, has advanced far enough to justify the work.

The proposed filter at Jerome Park Reservoir, plans of which were completed during the latter part of 1907, is still awaiting the appropriation necessary to carry on the work. The plans for the filtration of the waters of Oakland Lake are completed and await the authorization of the necessary expenditure.

The investigation of the general distribution system is now under way with the intention of reinforcement wherever found necessary both by additional mains and cross-connections and by the redistribution of hydrants and the replacement of those of a size insufficient to provide an adequate fire engine supply.

The principal work of the department during the past year has been the completion and putting into operation of the high pressure fire system. After numerous preliminary tests, both of speed of operation and ability to stand the high pressures applied, the system in Manhattan was formally put into operation on July 6th, 1908, and was called on for its first fire on July 9th. How successful it has been may be ascertained from the press reports of the large fires in the districts where it has been in operation. Plans were prepared for extensions covering three separate areas of special fire hazard and were submitted to the Board of Estimate and Apportionment. In the early part of November that Board authorized the construction of one of the proposed sections and later in the month, the Board of Aldermen approved the proposed extension to cover the territory bounded by Houston Street, the Bowery, James Street and the East River. To properly cover this area about 110 000 lin. ft. of mains will be laid, with 600 hydrants. No increase in the number or size of the pumping stations will be required, the present stations having capacity enough.

BROOKLYN.

The average daily consumption of water in the boro for 1907 was 135.6 million gallons and for 1908 it has probably exceded 142 million gallons. The increase has been made up in part by improvements and extensions in the existing driven wells, and infiltration gallery plants, and by the installation of additional driven well plants, among which may be included the Titus Sixth Street plant, located within the boro limits. At present there are under construction additional driven well plants from which an increase is expected of from 13 to 18 million gallons per day, located at Lynbrook, Rockville Center and Trotting Course Lane. Contracts have also been prepared for three additional plants on Long Iland, that are expected to further increase the supply during the coming year from 9 to 12 million gallons per day. The above increases must not be taken as net, as in all probability some of the existing sources of supply will be affected by the new wells.

To supplement the existing condit capacity a contract was let for the furnishing and laying of 83 500 lin. ft. of 72-in. steel pipe. Work on the contract has been started. This steel condit is to be used as a force main for direct pumping from the sources of supply to the distribution system, and to take care of this pumpage plans and specifications have been prepared for two large pumping stations located at Wantagh and Massapequa, together with the necessary plans and specifications for pumping machinery and boilers, designed for a total pumping capacity of 70 million gallons a day. These two plants will pump directly into the distribution system from the new infiltration galleries located at Wantagh and Massapequa, both of which were completed and put in full service during the past year.

Additions were made to the boiler and pumping capacity at the Ridgewood south side plant, including about 1 100 boiler horse-power and a 20 million gallon pumping engine. At the Ridgewood north side plant some work was done on the new pumping station and all of the pumping machinery, consisting of four new pumps with a total daily capacity of 75 million gallons, has been completed at the shops. Additional pumping capacity is being furnisht at Mount Prospect thru the installation of a 10 million gallon engine, and the Millburn pumping station is likewise receiving extensiv renewals and extensions.

For the distribution system 24 miles of pipe was laid and there were set 600 gates and 800 hydrants, thus bringing the total mileage of water mains laid to January 1st, 1909, up to 870 miles; the total number of gates to 12 400 and the total number of hydrants to 12 500. Much work was done in the way of replacing old tuberculated mains by new and larger ones. All of the distribution gates of the City are receiving a periodic and thoro overhauling, something which the department had not been able to do in previous years.

The last of the high pressure fire service stations, the main station located at the foot of Joralemon Street, was put in service and the boro is now equipt with three special fire service stations, one at Coney Iland, one at the corner of St. Edward's and Willoughby Streets, and one at the foot of Joralemon Street, which serve a special system of mains consisting of about 23 miles of pipe, 1 077 gates and 774 hydrants. These stations have proved so efficient and so acceptable to the Fire Department and to the citizens of the boro, that provision is being made for a further extension; in fact, one contract has already been prepared and awarded for the laying of 20 000 ft. of pipe, 130 gates and 95 hydrants, as an extension to the Coney Iland system.

RICHMOND.

There was laid in the aggregate about 8 miles of water mains, varying in size from 8 to 20 in. Owing to the fact that the City has not, as yet, taken over the three private water companies' plants, the department is hampered in the way of establishing a more thoro and efficient water supply for the boro. As is generally known, all the water delivered to the consumers is from wells and is pumpt directly into the mains. The City has but one pumping station on the iland.

THE METROPOLITAN SEWERAGE COMMISSION.

Associated with the work of water supply for the City is the question of sanitation, and the work of the Metropolitan Sewerage Commission should be taken up here. This is an official body, created in accordance with a special act of the Legislature to investigate and report on means for permanently protecting and improving the sanitary condition of the waters of New York harbor and vicinity, and is the successor of the New York Bay Pollution Commission. The report is to be made by May, 1910. The work thus far done has been chiefly of an investigating character and is preliminary to the more final and creativ work of the Commission. Since the latter was organized in January, 1908, the resources and scope of its investigations have been much extended. It has establisht a laboratory and employed trained assistants for the analyses of water and solid matter deposited from the water upon the bottom of the harbor. The principal object of these analyses has been to determin to what extent the sewage now discharged into the harbor produces injurious conditions and to what extent and under what circumstances it may be disposed of in the same general manner as at present, but without injury to the public health and welfare. A report dealing with this subject and containing a digest of all similar information collected by other authorities, is in preparation.

With the assistance of the U. S. Coast and Geodetic Survey, an exhaustiv study is being made of the phenomena of New York harbor, with special references to the effects of the currents in transporting and disposing of sewage. Investigations have been begun to determin the locations, sizes and capacities of all the principal sewers in the metropolitan district, as well as the condition and adequacy of the present sewerage systems. Careful studies were made of the trunk sewerage projects of the Passaic Valley Sewerage and the Bronx Valley Sewerage Commissions, both of which projects, in the opinion of the Metropolitan Sewerage Commission, threaten to add materially to the pollution of the harbor. They have consequently been opposed by the latter Commission before the proper authorities. Estimates of the present and future populations and their distribution in future years have been made to cover the Metropolitan district of New York and New Jersey.

DEPARTMENT OF DOCKS AND FERRIES.

If New York is to maintain its supremacy as the commercial center and the principal seaport of the country, it is apparent that not only must the Federal Government keep up the work of improving the harbor and its entrances, but the municipality itself must adopt a liberal policy toward the large shipping interests that center here, and at least keep up with the increasing demands for docking facilities; otherwise trade will go elsewhere. There is evidence already that the commerce of some of the other Atlantic seaports is increasing relativly more than that of New York, and there is grave danger that our city will suffer far more by such a comparison in the not distant future if it is not alive to the situation. The importance of the work of the Department of Docks and Ferries cannot, therefore, be too strongly emphasized, and its plans for the improvement of the water front should receive the support of all who have the interests of the City at heart. A brief description of what has been accomplisht by the Department follows.

DOCKS.

On the Chelsea section, which will be the new transatlantic steamship terminal extending from Bloomfield to West Twenty-third street, the department is now erecting eight new double-decked steel sheds, on piers 800 ft. long by about 125 ft. wide, with a double-decked steel bulkhead shed extending the whole length of the section, about one-half mile. The contracts for the steel work aggregate about $5 000 000 and the whole terminal will be completed during the coming year. At present about all of the steel work has been erected, and work has commenced on the reinforced concrete front, forming the half-mile front elevation of this shed system.

Work has begun on the construction of eight new piers on the South Brooklyn section of the water front, an improvement estimated to cost $10 000 000. The preparatory work has been let and work begun on a dredging contract, aggregating about four million cubic yards of material. Plans have been prepared for and work will shortly begin on two concrete piers with a retaining wall at Whale Creek, a branch of Newtown Creek. This work is estimated to cost about half a million dollars.

A number of new piers have been constructed and the bilding of the regular bulkhead, or river wall, in various places has continued. Several hundred feet of this wall was constructed along the East River opposit Blackwell's Iland on a difficult rock bottom, which required blasting out under water, prior to bilding the wall, to obtain a footing for the concrete bagging forming the sub-foundation. A concrete retaining wall was built in the water around one of the ends of North Brother Iland for a length of 1 900 ft., forming a basin which will create, when filled in, 4 acres of newly made land.

FERRIES.

At the Manhattan terminal for the Thirty-ninth Street ferry to Brooklyn, the department is erecting an extensiv ferry terminal. The steel ferry house, forming its easterly end, is about completed at a cost of $648 000. Work on the westerly end has been let at a cost of about $450 000 and the steel erection has commenced. This, when completed, will be the most extensiv ferry terminal in New York. On the upper story of the structure, extending over the slips themselves, will be located the department offices, on top of which will be a recreation roof. Plans are being prepared for a ferry house at the Brooklyn terminal of this ferry to cost about $330 000, and for a ferry house at Stapleton, Richmond, at a cost of about $300 000.

About 2 000 men are employed constantly in the regular work of the department, by day labor, and are engaged in operating 21 piledrivers, 3 tugboats, 5 launches, about 20 scows and derricks, and in the maintenance of yards where concrete blocks are made, machine shops located, granit cut, etc. All of this plant is used in the maintenance and repair of the extensiv dock system owned by the City and in bilding the river or bulkhead wall.

JAMAICA BAY IMPROVEMENT COMMISSION.

During the year the Commission has been in consultation with the War Department with a view to framing a plan for the improvement of Jamaica Bay, and the making of recommendations regarding the order of such improvement, with the cost thereof and the proportion to be borne by the City of New York. The scope of the work includes the creation and maintenance of an entrance of adequate width and depth, of interior channels and the reclamation of adjoining meadow land. The material to be handled ultimately in connection with this work will probably excede that required for the construction of the Panama Canal. Considerable progress has been made in the studies, but no progress report will be available until after the completion of the office work connected with the War Department surveys of the past season.

In connection with this it is well to mention the work done by the Federal authorities in the way of improving the south entrance to New York harbor. The new Ambrose channel is now, I believe, used by the large steamships in place of the old tortuous ship channel. This change must result in great convenience to those navigating the large liners, and is one of the improvements necessary for the future supremacy of New York as a commercial port.

DEPARTMENT OF BRIDGES.

Brooklyn Bridge.

The temporary extension to the Park Row station, Manhattan, was completed. Thru six-car elevated train service at all hours was inaugurated on January 27th, and has been maintained since. The roadways were widened on the Manhattan approach west of Pearl Street. A complete electrically operated signal system has been installed on the suspended structure, for the spacing of elevated trains. At the Brooklyn end an elevated approach was constructed and is used by a large portion of the trolley cars crossing the bridge, thus removing them from the streets leading to the bridge, leaving the streets more free for vehicular traffic.

WILLIAMSBURG BRIDGE.

The new subway station in Manhattan was completed. It was opened for use of the trolley cars on May 19th, and for elevated trains on September 16th. All of the trolley cars and elevated trains of the Brooklyn lines, which cross the bridge, run into this station, and its use has greatly facilitated traffic on the structure. The operation of the elevated train service has been continuous since it was inaugurated on September 16th.

MANHATTAN BRIDGE.

The anchorages were completed, as were the steel piers for the erection of the cables. The elevation of the center line of the latter at the piers is 322.5. The first wire rope for the support of the footbridges was raised into position June 15th and the last one ten days later. The footbridge floor was then erected and machinery installed for the stringing of the wires for the main cables. The first wire for the latter was drawn across the river on August 1st, and the last one on December 10th. There are four cables, each composed of 9 472 wires, and the stringing of this great number in such a short period, showed the use of a very efficient plant and activ prosecution of the work, and reflects great credit on the engineers and contractors in charge.

QUEENSBORO BRIDGE.

The erection of the steel superstructure of the main bridge, formerly called the Blackwell's Iland Bridge, was completed June 15th. Work on the approaches, including the laying of footwalks and trolley tracks, and paving of the roadway has progrest satisfactorily and all contract work necessary before the opening of the bridge is nearing completion.

OTHER BRIDGES.

The University Hights bridge, connecting Two Hundred and Seventh Street, Manhattan, with One Hundred and Eighty-fourth Street, Bronx, was opened for public use on January 8th. It consists of a draw span of 268 ft. resting on a center pier and of a fixt steel span and a masonry approach at each end.

The old draw span of the Madison Avenue bridge, which connects Madison Avenue, Manhattan, with One Hundred and Thirty-eighth Street in the Bronx, was removed to a temporary site about 500 ft. south of the old site, on June 9th. Foundation work is in progress for the new bridge and the steel for the superstructure is being fabricated.

The Borden Avenue Bridge, in the Boro of Queens, which crosses the Dutch Kills, was completed and opened to traffic May 25th. It is a retractile bridge, with a span of 67 ft. Two trolley tracks cross it.

The Pelham Bridge, Boro of the Bronx, which carries the Eastern Boulevard over Eastchester Bay, was opened to traffic October 15th. It consists of six reinforced concrete arches of 115 ft. span each, and a two-leaf steel bascule lift span of 60 ft. clear.

THE MUNICIPAL OFFICE BILDING.

Plans have been made, under the supervision of the Bridge Department, for this 25-story steel frame office bilding of classic design, to be constructed on the block bounded by Tyron Row, Center Street, Duane Street, and Park Row, Manhattan.

THE NEW YORK INTERSTATE BRIDGE COMMISSION.

This Commission, in coöperation with a similar commission in New Jersey, has studied the sites for bridges across the Hudson River in the vicinity of Fifty-seventh Street, One Hundred and Tenth and One Hundred and Seventy-ninth Streets. A report of the Consulting Engineers, Messrs. Boller and Hodge, was recently made to the New York Commission, and its conclusions have been extensivly publisht in the press. According to an abstract of this report publisht in the technical papers, the Consulting Engineers estimate the cost of a 3 200-ft. span, suspension bridge at Fifty-seventh Street at $30 000 000; of a cantilever bridge of 1 400-ft. span at One Hundred and Tenth Street at $15 000 000; of a cantilever bridge at One Hundred and Seventy-ninth Street at $10 000 000. It is understood that all of these estimates include land damages and approaches. Both Commissions are considering the question of the site and proper location for such a bridge, with due regard to all questions entering into the discussion, and the New York Commission will transmit a report to this year's Legislature.

A suspension bridge at West Fifty-seventh Street, with the unprecedented span of 3 200 ft., has been proposed by the North River Bridge Company, which has a charter for a bridge at that point. Its estimate of the cost, including right-of-way, damages, approaches, etc., is $70 000 000. The Commission's engineers, in their estimate of a bridge at Fifty-seventh Street, have omitted the subway and some other features proposed by the Bridge Company, so as to make it comparable with their estimates for the bridges at other sites.

PUBLIC SERVICE COMMISSION FOR THE FIRST DISTRICT.

The work of the year consisted largely of supervising the construction of the Brooklyn Loop Lines in Manhattan, the completion of the Brooklyn-Manhattan Railroad (Contract 2), and minor details of the Manhattan-Bronx Railroad (Contract 1). Work of a comparativly minor character consisted of the proposed improvement by the addition of tracks at Ninety-sixth Street, and the new shuttle service at Bowling Green. This work of construction and the extensiv studies of designs for additional subways constituted a large part of the Commission's activities for the year. The work of the Pennsylvania Tunnel and Terminal Company, and that of the Hudson Companies' tunnels has also been under the Commission's supervision.

BROOKLYN LOOP LINES.

Work on the Manhattan sections commenced in May, 1907. Changes were made in the plans whereby the grades were reduced from a maximum of 5½% to a maximum of 3%, and the hight of the tunnels increast so as to admit the use of cars of standard cross-section. These changes are believed to have increast the operativ capacity of the loop 25%, and by the introduction of larger cars, its traffic capacity 50%. They have also permitted the substitution of one station at Canal Street with all the tracks on a level for the double-deck stations at Leonard-Franklin and Howard-Grand Streets. Provision was made in the designs at the intersection of Center and Canal Streets so that a subway can be bilt on Canal Street passing under the present station.

Application has been made to the Board of Estimate and Apportionment that the size of the Chambers Street station be increast from four to six tracks, so arranged that the two westerly tracks may be extended down Nassau Street, and two of the others down William Street with a view to their ultimate extension across the East River to Brooklyn. An extensiv revision of the design of this station was also necessary to conform to the plans of the proposed new municipal bilding. As the foundation for the latter must be carried to a much greater depth than was required for the subway, it was necessary in May to stop work on subway construction at that point, since which time no progress has been made. Of the remaining sections 9-0-2 is 70% complete; 9-0-3, 63%; 9-0-4, 35%, and 9-0-5, 80%. The contract payments for 1908 amounted to $3 299 413.54, making the total to date $4 182 213.46.

A very interesting feature of the loop construction has been the work of underpinning the bildings, and many ingenious methods were devised by the contractors for the purpose.

CONTRACT No. 2.

Important progress was made in completing the Brooklyn-Manhattan Railroad, a work of great importance in affording rapid transit facilities between the two boros. The portion of this road from Bowling Green station to Boro Hall, Brooklyn, was opened for operation with appropriate ceremonies on January 9, permitting thru trains to be run from Manhattan and the Bronx to Brooklyn. With the exception of the subway under the Harlem River, this was the first submarine traffic tunnel in operation about New York, and its popularity was immediately shown, resulting in the markt relief of the traffic conditions on the Brooklyn Bridge. After the many predictions of failure made by the sensational press, it is a satisfaction to know that careful observations of the river tubes have not detected the slightest movement in any direction, and no structural defects have developt. The leakage, which is comparativly slight, has shown a markt tendency to decrease.

On May 1st, 1908, the section from Boro Hall station to the terminus of the road at Atlantic Avenue station was opened for passenger service, whereby the traffic over the Brooklyn Bridge was further relieved. Already the congestion, during rush hours, at the Brooklyn stations of the subway is fast approaching the conditions which formerly existed over the Brooklyn Bridge, and the early completion of the Brooklyn Loop is the evident remedy. At this date practically all details in connection with the construction and operation of the Brooklyn subway have been brought to a successful conclusion. Considerable work remains to be done, however, in the restoration of vaults and sidewalks on Fulton Street, and other incidental work.

SOUTH FERRY SHUTTLE TRAIN SERVICE.

Work was begun in the vicinity of Bowling Green station on August 14th, carrying out a construction plan for this service between that station and the one at South Ferry. This will permit all trains to run thru to the Atlantic Avenue terminal, thereby doubling the present service to Brooklyn. The cost is not to excede $100 000, and the contract payments to date equal $47 891.71.

CONTRACT NO. 1.

On August 1st, 1908, the elevated structure from Two Hundred and Thirtieth Street and Broadway to Van Cortlandt Park was opened for operation, this being an extension of the original Manhattan-Bronx subway of Contract 1. Since the opening of this extension one can travel from the Long Iland R. R. station in the heart of Brooklyn north nearly to the northerly limit of the Bronx without change, and on payment of but one five-cent fare. There remains to be bilt the terminal station in the Bronx, as soon as its definit location is determined. The temporary station at One Hundred and Eightieth Street is still in use.

Work was begun October 1st on the changes at the station at Ninety-sixth Street and Broadway for the addition of new tracks to relieve the congestion of train service, due to the grade crossings at this junction of the East and West side branches. The estimated cost of the improvement was $850 000. The operating company reported early in December the satisfactory development of an automatic speed control signal which might render the new tracks unnecessary at the present time, so it was decided to hold the work in abeyance until the efficiency of the signal was practically demonstrated. The work of changing the large water mains, which had begun, was, however, to be completed. These three mains are to be moved out of Broadway to West End Avenue. Payments on account of this work have been made to the amount of $56 276.46.

Among other improvements made to the existing subway was the completion of the ventilating openings on Broadway between One Hundred and Thirty-ninth and One Hundred and Forty-third Streets, and at the One Hundred and Forty-fifth and One Hundred and Fifty-seventh Street stations. The capacities of the elevators at the One Hundred and Sixty-eighth Street and One Hundred and Eighty-first Street stations of the Fort George tunnel were increast from 8 000 lb. to 11 000 lb.

The total payments to date on account of subway construction are as follows:

Contract No. 1, regular work	$34 483 000.00
Contract No. 1, extra work	5 639 061.65
Contract No. 2, regular work	1 853 908.62
Contract No. 2, extra work	1 473 978.70
Brooklyn Loop Lines, regular work	4 182 213.46
South Ferry Shuttle Service, regular work	47 891.71
Additional tracks north of Ninety-sixth Street, regular work	56 276.46
Total	$47 736 330.60

The Fourth Avenue Subway, Brooklyn.

On May 22, 6 contracts were awarded for the construction of those portions of this subway from the Manhattan Bridge to Forty-third Street and Fourth Avenue, subject to the approval of the

Board of Estimate and Apportionment. The total cost, based on the successful bids, is estimated to be:

For railroad construction	$14 886 763.65
For pipe gallery construction	999 617.55
Total	$15 886 381.20

The approval of these contracts by the Board of Estimate and Apportionment has not yet been given.

GENERAL.

Studies have been made for a subway under Canal Street from the North River, intended to connect, by way of the Manhattan Bridge, with the Fourth Avenue subway in Brooklyn.

The Commission has completed its studies for the subway on the Lexington Avenue route combined with the Gerard Avenue, Jerome Avenue, Southern Boulevard and Westchester Avenue routes, and the approval of the Board of Estimate, requested on February 5, has since been obtained. On account of the magnitude of this work, it was deemed advisable to cut it into 16 sections, approximating in value from three million to four million dollars each, and the preparation of the plans and contracts has proceeded on this basis.

Studies have likewise been made for the Brooklyn sections of the so-called Brooklyn Loop Lines. The most feasible route appears to be down William and Beekman Streets to the East River, under the latter and Cranberry Street to Fulton Street, Brooklyn; thence under the latter and Willoughby Street to the Flatbush Avenue extension, where connection would be made with the line crossing Manhattan Bridge. The designs of the tunnel provide for a capacity of 100 000 passengers per hour, about three and one-half times the number carried by the elevated trains over the Brooklyn Bridge at present.

The new subways under construction, with those for which contracts have been awarded and those in preparation for contract, total approximately 36½ miles, and the estimated cost of their construction is $129 200 000.

THE PENNSYLVANIA RAILROAD IMPROVEMENT.

Altho it is not being carried on directly by the Municipal Government, the progress of the Pennsylvania improvement deserves special mention here, as the completion of this magnificent work will mean so much to the City.

At the end of 1908 the excavation for the Sunnyside yard, between Woodside and Thompson Avenues, Queens, was about 80%, and the bridge and viaduct work about 50% completed. The approaches to the East River tunnels from this yard were about 70% completed. The four tunnels from Front Street, Long Iland City, to East Avenue are entirely finisht, as are the four tunnels under the East River, including the concrete lining, but there yet remains some concrete to be placed in the four shafts. The four crosstown tunnels between First and Seventh Avenues, Manhattan, are practically completed, the only work remaining to be done being the cleaning up of rubbish and the rodding of the electric condits. The excavation at the large terminal station, together with the retaining wall surrounding it, are finisht and the bilding itself is about 50% completed. The excavation and iron lining for the two Hudson River tunnels are completed and about 50% of the concrete lining is done. The two tunnels under Bergen Hill are also completed. The work of track-laying and electrification has not been started on any of the work. Indications point to the early completion and operation of this improvement. Meanwhile the question is often askt: How is the multitude of persons who will use this station to be handled on their arrival in the city, and what provisions are being made by the authorities to meet the conditions which will soon confront them?

THE HUDSON COMPANIES' TUNNELS.

The work of this company was delayed in the early part of the year by the financial stringency, which affected so many other enterprises in the vicinity of the City. Work, however, was gradually resumed, and since the 1st of September practically all the work in the tunnels has been in activ progress. During the year the construction of the Sixth Avenue extension was carried from

Christopher Street and Sixth Avenue to Twenty-seventh Street and Sixth Avenue, and trains have been in operation as far north as the Twenty-third Street station since June 15. In the downtown tunnels the work has progrest about 900 ft. on the Cortlandt Street tube, and about 500 ft. on the Fulton Street tube, and about 300 ft. on the parallel tracks under these streets. The pneumatic caissons comprising the structure of the approaches of these tunnels to the Church Street terminal have all been sunk, the caissons themselves practically completed. The subsurface improvements and the streets themselves are being restored. By the end of January it is hoped to have the Cortlandt Street tunnel connected across the river, and about the 1st of July to be ready for the operation of trains from Hoboken to the Church Street terminal, New York City. The bildings overlying this terminal were completed and have been occupied since May 1st. The underground floors, forming the station itself, have been finisht with the exception of the track and interior fittings, and the latter work is in activ progress. In addition to this, much miscellaneous work has been done under the direction of this company which cannot be described here for lack of space.

THE GRAND CENTRAL IMPROVEMENT.

Much work has been done, and considerable progress made, in spite of the difficulties of carrying on the construction work without interfering with the operation of the hundreds of trains which arrive at and depart from the station daily. On account of this the work is necessarily slow.

THE LONG ILAND RAILROAD COMPANY.

As far as results are concerned probably the most important piece of work done during the past year by this Company within the City limits, was the completion of the elimination of all grade crossings on the Manhattan Beach division, between Bay Ridge and New Lots Road, East New York, inclusiv. This is further covered under the heading of the Brooklyn Grade Crossing Commission. Work has been in progress on this undertaking for about three years, and the elimination of the crossings was effected almost entirely by a modification of the railroad grades, the streets being carried over or under the railroad. In this operation the expense is supposed to be divided equally between the City and the railroad company, but it is claimed by the latter that at least two-thirds of the expense falls to the railroad on account of rearrangement of their facilities. The section of the same division between Manhattan Beach Junction and Manhattan Beach has also been the scene of considerable activity. Here the railroad grade is elevated from 16 to 18 ft. to allow the streets to be carried underneath at their existing grades. The Brighton Beach tracks of the Brooklyn Rapid Transit were similarly treated, but the elevation of that line was practically completed last spring.

The Pennsylvania railroad improvements necessitate some radical changes in the Long Iland tracks, and work has just started on the reconstruction of what is known as the main line between Jamaica and Winfield, for the purpose of eliminating all existing highway crossings in that territory. The railroad grades, after conference with the City's engineers, have been so establisht as to allow the opening of future streets without any modification in the railroad grades. This is to be made at once into a four-track line and the property has been taken and the bridges designed for its ultimate extension to six tracks. The concentration of all passenger traffic on this main line, and the fact that it is the only connection to the Pennsylvania tunnels, has necessitated the construction by the company of what is known as the Glendale cutoff, about a mile and a half in length, to connect the existing tracks of the Rockaway Beach division with the main line, so that the electrified trains of the Rockaway territory can be carried into Manhattan by way of the tunnels. This concentration of passenger traffic on the main line likewise carries with it the use of the present Montauk division of the system primarily for freight purposes, which change in turn has required the construction of what is known as the Montauk freight cutoff in Long Iland City. This is an overhead freight line, connecting the railroad's freight tracks at the west end of the Sunnyside yard with the Greenpoint Avenue yard on the Montauk division. The construction of both the Glendale and Montauk freight cutoffs is well under way, and both should be completed in the spring or summer of 1909.

BROOKLYN GRADE CROSSING COMMISSION.

The Brighton Beach Improvement.

The work of the Commission on this improvement was completed during the past year. The work was originally divided into three sections, as follows: Section 1: The elimination of grade crossings at Prospect Place and Park Place, this work being finisht in 1904; Section 2: The deprest section from Church Avenue to Avenue H, a distance of about 6 800 lin. ft.; Section 3: The elevated portion extending from Avenue H to a point 700 ft. south of Neptune Avenue, a distance of about 19 500 lin. ft.

From Church Avenue south four tracks have been laid for the operation of local and express service. Six streets are carried over the deprest section, and 17 streets are bridged on the elevated portion, thus eliminating the grade crossings from 23 streets. The principal items of work accomplisht on Sections 2 and 3 are as follows, about one-quarter of this work being done during the past year.

		Section 2.	Section 3.
Excavation	cubic yards	230 000	30 650
Fill	cubic yards	....	467 000
Concrete	cubic yards	43 900	25 100
Steel in highway and railroad bridges	tons	608	2 451

The station bildings and platforms over the whole line were bilt by the railroad company at its own expense.

The Bay Ridge Improvement.

The work done on this improvement during the past year is represented by the following figures.

Masonry of all classes	2 834 cu. yd.	$ 17 026.80
Foundation excavation	1 995 " "	1 795.50
Excavation	314 137 " "	93 680.68
Total		$112 502.98

Permanent track, 41 039 ft.

The above excavation was placed between New Lots and Avenue G, on the Manhattan Beach division.

These highway bridges were completed and put in service during the year 1908: Avenue H and Albany Avenue, Brooklyn Avenue, Flatbush Avenue, Nostrand Avenue, Ocean Avenue, East Fourteenth Street, Coney Iland Avenue, Ft. Hamilton Avenue, Fifty-second Street, Eighteenth Avenue and Fifty-third Street, Seventeenth Avenue, Sixteenth Avenue and Fifty-ninth Street, Sixtieth Street, Fifteenth Avenue and Eleventh Avenue.

These railroad bridges were completed and put in service during the year 1908: New Lots Road, Rockaway Avenue, East Ninety-fourth Street, East Ninety-second Street, Remsen Avenue, Wyckoff Avenue, Ralph Avenue and Avenue D, Elm Avenue, Kouwenhoven Road, Utica Avenue, Avenue G, Avenue J, Avenue K, Locust Avenue and Chestnut Avenue.

The payment made during the year for steel was $54 657.00.

BORO PRESIDENTS' BUREAUS.

The work under the direct supervision of the Boro Presidents is described under the following headings: Topographical Bureau, Bureau of Highways, Bureau of Sewers, Subsurface Work, Bureau of Public Bildings and Offices, Bureau of Bildings and Refuse Disposal.

TOPOGRAPHICAL BUREAUS.

BRONX.

Four final sections, including 1 575 acres, were prepared, adopted by the Board of Estimate and Apportionment and filed. One more section of 375 acres was adopted and ordered filed. Four additional sections of 1 717 acres were calculated. All data on the sections are in terms of co-ordinates of the United States Coast and Geodetic Survey triangulation. Sixty-four procedings were initiated for acquiring title. One thousand maps were furnisht Commissioners in street opening procedings. The titles of 26 streets were vested in the City. The new system of house numbers was completed and the owners notified. In the field 460 miles of linear measurements were made, 1 400 monument points and 560 stone monuments set, 19 miles of streets were completely monumented and monuments were tested and reset, on account of improvements, on 50 additional miles of streets. Eighty streets were surveyed for condemnation procedings, including levels to show grade damage.

BROOKLYN.

Considerable progress was made in completing the map records of the Boro. Preliminary and final surveys on highway improvements were carried forward and a great number of rule and damage maps were completed in street openings and other procedings.

QUEENS.

The topographical survey of the boro is practically complete. The triangulation survey was finisht and the bureau is now in receipt of the needed information from the U. S. Coast and Geodetic Survey office for co-ordinating the outlying street system. A tentativ layout of the streets and grades has been approved by the Board of Estimate to date for 22 379 acres, which is about one-third of the area of dry land in the boro. The final maps, upon which the legal opening of streets, preliminary to physical improvements, is dependent, have been prepared for large portions of the thickly populated sections of the Second and Fourth wards. A great impediment to the adoption of those not yet approved will probably be removed in the near future by the signing of an agreement between the City and the Long Iland Railroad Company, which will provide for eliminating all existing grade crossings as soon as feasible, replacing them by crossings above or below the railroad grade, and supplying additional ones as they are to be needed in the future.

A large portion of the force has been occupied in the preparation of maps for the legal opening of streets, and the bureau is now more successfully coping with this portion of the work than it has in the past. In connection with this a systematic search is being conducted into what had been accomplisht in this direction in the earlier history of the territory now comprized within the limits of the boro. The results have been surprizing, and beyond what was anticipated. Had the investigations not been started and vigorously pursued, it is possible that the City, or the property owners, in the future would have paid for land for street purposes which had already been properly acquired.

RICHMOND.

The work of the bureau has been continued, consisting of survéys from the basic triangulation to the completed maps, showing the existing conditions, followed by the studies of street systems, parks, boulevards, etc., with the preparation of "damage" and "benefit" maps for street openings.

BUREAUS OF HIGHWAYS.

BRONX.

Eight and one-half miles of streets were paved, making a total mileage of 113. Ten miles were regulated and graded, making a total of 297 miles. One hundred and twenty-five contracts were in force, and those completed during the year cost a total of $1 894 000. The amount certified on works in progress and completed during the year was $1 691 771.

The following special work under contract was finisht: the King's Bridge Road Transverse and the Tremont Avenue Transverse Road, in connection with the Grand Boulevard and Concourse. In addition transverse roads under the latter have been begun and are in an advanced stage at Burnside Avenue and Two Hundred and Fourth Street, and one at One Hundred and Sixty-seventh Street is begun. Work on the Grand Boulevard and Concourse itself is approaching completion, and the arch and retaining walls adjacent to One Hundred and Seventy-fifth Street, where the latter passes under the concourse, have been completed.

An extension of the bridge across the Bronx River at Tremont Avenue is in progress, and the regulating and grading of Broadway, which has been going on for several years, is completed.

The six-tracking of the New York, New Haven & Hartford Railroad Company's lines within the limits of the boro has been steadily advanced and most of the bridges across the highways or carrying the highways across the tracks are practically finisht. The elimination of grade crossings on both this and the New York Central Lines has been in progress for several years. The work is so nearly completed that there remain only three such crossings to be eliminated in the whole boro; those at King's Bridge Road, West One Hundred and Thirtieth Street and West One Hundred and Thirty-first

Street on the Putnam Division of the New York Central. Steps are being taken to eliminate these three, and it is hoped that by 1910 the Bronx will be free from all railroad grade crossings.

MANHATTAN.

Miles of new pavements laid during 1908:

Wood block	1.86	miles
Granit block	5.225	"
Belgian	.032	"
Sheet asphalt	4.93	"
Asphalt block	5.198	"
Macadam	.537	"
Total	17.782	"

In addition to the above the extension of Riverside Drive between One Hundred and Thirty-fifth and One Hundred and Forty-fifth Streets has been completed at a cost of approximately $1 600 000.

BROOKLYN.

A considerable amount of assessment paving, repaving and repair work was carried out during the year; 23½ miles of new pavements were laid, of which about 19⅜ miles are sheet asphalt. The total mileage of paved areas in the boro now amounts to 673¾ miles.

Some experimental pavements were laid, chief among which was the resurfacing of Beverly Road from Ocean Parkway to Flatbush Avenue, done by the repair division of the bureau, where about 19 000 sq. yd. of macadam was resurfaced and treated with a heavy Tarvia oil. In the treatment of this road the macadam pavement was finisht in the usual manner, stopping just short of the hard finish, leaving the surface more or less open. On this surface was spread and broomed a liberal coating of the oil, after which a coating of screenings and small stone was rolled in.

On Eighteenth Avenue, between Eightieth and Eighty-third Streets, three experimental pavements were also laid. A block was laid by The Barber Asphalt Company, of bitulithic concrete, using the regular size macadam stone with tar mixtures. On the second block a cement-concrete macadam was laid by the repair division of the bureau, using 4 inches of macadam stone on the old base bonded with a mortar bond of 1 part bituminous cement and 3 parts trap-rock screenings. The cost of this complete was about 52c. per sq. yd. On the third block there was laid by the Texas Company, on the old macadam as a foundation, an asphaltic mastic composed of graded mineral aggregate and "Texaco" asphalt, giving a thickness of 2 inches. The cost of this work was 75c. per square yard.

The Texas Company has also laid two stretches of pavement without cost to the City; the first two blocks on Nevins Street, on a foundation furnisht by the repair division, composed of the old granit blocks relaid and grouted with a 1:3 mortar. This type of foundation and the Texas asphalt are novelties for this boro. The binder is 1 in. thick and the mastic 2 in., and the experiment was made to determin the advisability of admitting the Texas asphalt in competition with other asphalts called for in the old highway specifications. The second experiment made by the company was the resurfacing of Clinton Street, between Pierrepont and Fulton Streets. This is a street of exceptionally heavy traffic, with a narrow roadway. Portable rotary mixers were used, and the old asphalt, originally laid thirteen years ago on a Rosendale cement-concrete foundation, was cut out, broken up, remelted, enriched with "Texaco" asphalt, with the addition of suitable mineral aggregate and immediately relaid. Very light rollers were used. If the work stands up thru the coming summer, the boro authorities expect it will show opportunity for great saving over present methods of tearing out and discarding old sheet asphalt material. By using portable mixers of large capacity directly on the street, it is expected that the operation of remelting, mixing and turning out the mastic can be maintained at such rates as to reduce the labor cost to a reasonable minimum. The interruptions by breakdowns of the small and ill-adapted machines used on Clinton Street were such as to afford no reliable cost data for such work.

In addition to these novel features a very large amount of repairing was done by the municipal asphalt plant at a cost not exceding the last contracts. About three million square yards of sheet asphalt are now out of maintenance, which shows the importance of this branch of the work in the boro. In addition, oiling as a preservativ and dust-preventiv on macadam roads was applied over about 68 000 sq. yd. of macadam roadways. Tarvia bond has been used and the cost of application, as reported, was 1.1c. per sq. yd.

QUEENS.

Miles of pavements laid during 1908:

Asphalt	0.41 mile
Asphalt block	0.96 "
Wood block	0.68 "
Total	2.05 miles

The amount is rather small for the great area of the boro, but is accounted for by the fact that no authorizations for either surface or sub-surface improvements were made from October, 1907, to June, 1908, on account of the financial conditions.

RICHMOND.

Miles of pavements laid during 1908:

Block Asphalt	0.49 mile
Bituminous concrete	2.12 miles
Macadam	1.93 "
Brick	0.18 mile
Total	4.72 miles

The most conspicuous piece of work has been the construction of the great St. George Ferry Approach retaining walls, and the awarding of a contract for yet another portion of similar walls. This fine improvement was so well described in Mr. L. L. Tribus' paper, read at the December meeting, that further description is unnecessary here.

BUREAU OF SEWERS.

BRONX.

Eleven miles of sewers and 116 receiving basins were bilt, making a total of 269.5 miles and 3 007 basins. Thirty-two contracts were in force on January 1, 1908, of an estimated cost of $1 966 000.

Forty-three contracts were completed during the year at a total cost of $470 477.54. Thirteen contracts were in force December 31. 1908, of an estimated cost of $2 080 441.63. Several important reinforced concrete sewers were under construction during the greater part of the year, viz.: Zerega Avenue (Avenue A), Pugsley Avenue (Avenue E), Truxton Street. Several large trunk sewers which failed on account of mud wave action were repaired or rebilt during the year.

MANHATTAN.

Three and seven-tenths miles of new sewers were bilt and 2.09 miles of old sewers were rebilt, a total of 5.79 miles. In connection with this work 63 receiving-basins were bilt. Of the new sewers 7 289 ft. were of brick, varying in size from 3 ft. 6 in. by 2 ft. 4 in., egg-shape, to 4 ft., circular. Ten thousand and forty feet were pipe sewers, mostly 15 in. in diameter. Of the sewers rebilt the size varied from 3 ft. 6 in. to 2 ft. 4 in., egg-shape, to 9 ft. by 6 ft. 6 in.. aqueduct shape.

It is often suggested that, on account of the reconstruction of the lower portion of Manhattan, resulting in the substitution of tall skyscrapers for smaller bildings, the sewer system of that section would require modification. It is found, however, that, altho the sewer system was designed and constructed many years ago, there has been no occasion to modify the plans. While the large office bildings are tenanted by a great business population during the day, the consumption of water does not vary with the population as it would in residential sections. The rainfall, which is the leading factor in determining the size of sewers to be used in the combined system. does not, of course, change on account of the hights of bildings. It is interesting to note that when the consumption of water is greatest in the office bildings it is least in other parts of the City.

BROOKLYN.

Under the jurisdiction of this bureau the following work has been carried forward:

1. The completion of the Gowanus flushing tunnel, 12 ft. in diameter and about 6 300 ft. in length, constructed at a total cost of about $750 000. The masonry work is complete with a small

exception at the intake at the head of the canal. The pumping equipment is about to be installed, of a capacity to deliver 30 000 cu. ft. per minute. This tunnel was driven thru soft ground under a water pressure of about 20 ft. head thruout, comprest air being used. The work has aroused considerable interest and was inspected by a number of engineers and societies. Construction was carried on thru considerable distances where coarse gravel caused running in the headings. All difficulties of this nature are reported to have been well met by the contractors on their own initiativ in pumping grout thru the crown of the tunnel back of the shield.

2. The completion of a large part of the Gold Street relief sewer, 12 ft. 6 in. in diameter, where it intercepts the Hanson Place sewer, to an outlet diameter of 14 ft. This work extends from Hanson Place and South Portland Avenue to the pier-head line at the foot of Gold Street, and is under contract at an estimated cost of about $800 000, in three sections.

3. The partial completion of the sewer in St. Nicholas Avenue and Scott Avenue, from Newtown Creek to the boro line, this being a 15-ft. sewer with several steep gradients where the velocity is broken by rough dividing walls and stept inverts designed for the purpose. The estimated cost is $600 000.

4. Much technical study was given in designing economic plans for the drainage of about 6 000 acres of the lowlands in the southern portion of the boro. This is an engineering work of magnitude and altho construction has only begun, it is believed by the Boro authorities that the coming year will bring about most radical changes in the great sections benefited by actual adoption and partial execution of carefully made plans for the disposition of sanitary and storm-water flow. There has been removed from the City map about 130 acres of useless basins, and procedings have been instituted to open Gravesend ship canal thru from Gravesend Bay to Sheepshead Bay, and for a storm-water outlet extending northerly about three-quarters of a mile, known as the Bensonhurst storm-water outlet. From the head of this canal the sanitary sewage is pumpt back to the Ninety-second Street outlet north of Ft. Hamilton, under the old plan, while a number of storm-water outlets feed into the open canal, and thence into the so-called ship canal, both of which have to be acquired for sanitary purposes. Procedings are also under way by

which the City will dispose of the land in the bed of old Coney Iland Creek and its tributaries.

5. Plans have been perfected for a sewage-disposal works with a capacity of 10 million gallons per day, to be located at this canal near West Twelfth Street. This will be a sprinkling filter with beds about 3 acres in extent. Other enlargements and installations of disposal works along Jamaica Bay are well advanced, and three large contracts under way, amounting to more than half a million dollars, will allow the development of a very large section of undevelopt lands below the Brownsville district.

6. Plans for storm-water relief sewers to remedy the inadequate service of the old sewers in a large portion of the bilt-up sections of the boro have been completed at an estimated cost of $3 500 000. These plans include a thoro system of relief for East New York, as well as for the great sections extending thru the heart of the boro, which are now affected by flooding.

QUEENS.

Three and one-half miles of sewers of various sizes were bilt during the year, including the finishing of the 15-ft. circular reinforced concrete sewer draining a territory of about 2 000 acres. The total is 5 miles less than the work accomplisht in 1907, this being due to the financial condition of the City.

RICHMOND.

Seven and five-tenths miles of sewers of various sizes were bilt during 1908.

SUBSURFACE WORK.

BROOKLYN.

Much progress was made by the Division of Substructures working under direction of the Consulting Engineer of Public Works in field surveys and in the office work of recording and plotting the location and character of structures occupying public streets in the most congested sections of the boro. The Corporation Counsel has drafted an ordinance which allows the collection of fees by the City for the use of the maps and the valuable information at hand, on applications made to the Boro President by public service corporations or other parties desiring to open the streets for any purpose. Requests from the various departments and bureaus of the City filed with the Boro President will be acted on under a similar system, without the fees set in the ordinance, and the result is expected to mean future scientific and economic utilization of our streets as a valuable property of the City.

BUREAU OF PUBLIC BILDINGS AND OFFICES.

Brooklyn.

The Hamburg Avenue and the President Street public baths have been carried to a point near completion, while the Eighth Ward market improvement has progrest satisfactorily to the extent of reclaiming about 10½ acres of land. The novel feature of this work, as laid out in the Boro President's office, consisted in the initial application of the percentage bid system involving a number of uncertain items, as well as crib work and three classes of dredging. The prices on the proposed work were so carefully estimated under a dozen or more items, that the average of five bids, as submitted, amounted to 99⅔%, the award being made at 92½ per cent. Dredging to the amount of about 100 000 cu. yd. has been confined to within a few yards of the amount originally estimated to be necessary. All but a very small proportion of the material dredged for working channels and in trenching for the permanent crib work carrying the concrete sea wall, has been taken out and deposited back of the temporary bulkhead, at a cost of 22c. per yard, which is less than half the cost of other dredging contracts under way in the vicinity, where the material is deposited at sea.

BUREAU OF BILDINGS.

Queens.

The following table shows the new bildings and alterations approved by the Bureau during the years 1907 and 1908.

	New Bildings.		Alterations.	
Year.	No.	Cost.	No.	Cost.
1907.....	3 936	$15 944 860	1 357	$1 557 151
1908.....	3 896	13 842 000	1 054	794 326

REFUSE DISPOSAL.

RICHMOND.

The completion and putting into operation of a high temperature garbage, ashes and refuse destructor, tho primarily a feature of maintenance work, was actually one of engineering moment, the bilding and chimney being of reinforced concrete thruout. The great achievement of the plant is the converting into innocuous slag of all waste materials, such as garbage, ashes, street sweepings, paper boxes, etc., without nuisance, and without the use of additional fuel other than that contained in the materials themselves. The plant has a capacity of about 60 tons per 24 hours, operates at temperatures from 1 200 to 2 200 degrees, and furnishes steam, not only for all the mechanical operations of the plant itself, but a surplus which is shortly to be used for electric lighting and slag utilization processes. This is an encouraging report of the plant, so well described in the paper read by Mr. John T. Fetherston before the Society at the April, 1907, meeting.

DEPARTMENT OF PARKS.

MANHATTAN AND RICHMOND.

St. Nicholas Park.—The work in this park, between One Hundred and Thirtieth and One Hundred and Thirty-fifth Streets, was prosecuted to completion during the year and thrown open for public use. This, with the upper section between One Hundred and Thirty-fifth and One Hundred and Forty-first Streets, completes that part of the park which lies between St. Nicholas Avenue and St. Nicholas Terrace, leaving four blocks between the Terrace and Amsterdam Avenue, from One Hundred and Thirty-sixth to One Hundred and Thirty-eighth Street, unimproved.

Colonial Park, One Hundred and Forty-fifth to One Hundred and Fifty-fifth Street, west of Bradhurst Avenue.—The improvement of that portion north of One Hundred and Fiftieth Street, begun in the latter part of 1907, was pusht to completion during the year and thrown open for public use. Plans have been prepared, as well as form of contract, specifications and drawings for the improvement of the remainder of the park south of One Hundred and Fiftieth Street and the work will be advertized shortly.

Central Park.—An appropriation of $100 000 was made available for continuing the installation of water supply and irrigation system on modern lines. Two contracts are in force and a third is to be advertized covering the expenditure of the entire appropriation. As stated in the last Presidential address, this system takes the place of the old ineffectiv sheet line pipes, which, thru long service of about fifty years, had become useless. The problem of remedying the defectiv surface and agricultural drainage of certain sections of the park were studied and considerable work accomplisht.

The new bridle road entrance was constructed from Central Park West in the vicinity of Sixty-second Street to the bridle road at Sixty-fourth Street. In connection with this work a new walk was also constructed. A contract has been prepared for a new entrance at Central Park West and One Hundred and Sixth Street, to be constructed in 1909. Work was begun in connection with a new comfort station in the Ramble in the vicinity of the Seventy-ninth Street Transverse Road at an approximate cost of $30 000. This station is to take the place of the present dilapidated one which is equipt with earth closets, and will be in use in the coming spring. A contract has been prepared for cleaning and concreting the bottom of, and otherwise improving, Conservatory Lake.

The Harlem River Driveway (Public Driveway).—In 1907 a new 6-in. water supply main was installed between One Hundred and Seventy-fifth and Dyckman Streets. During the past year a further appropriation was made available to continue the work and a contract was executed covering the section between One Hundred and Fifty-fifth and One Hundred and Seventy-seventh Streets, which work included the necessary appurtenances, branches, drinking hydrants, road hydrants, street washers, horse troughs, etc. Studies are being made for a new stone bulkhead to take the place of the wooden bulkhead and crib work along certain sections of the driveway.

Riverside Drive.—Considerable work was done in the way of improving this drive. New asphalt block gutters, requiring 175 000 blocks, were laid between Seventy-second and One Hundred and Twenty-ninth Streets. The grade of the drive was reconstructed and its entire length resurfaced. Sixty new road basins were bilt, thousands of feet of curb and edging reset, and new drainage systems installed.

It became necessary for the department to raise the grade of the drive at the south end of the viaduct, carrying the drive over Manhattanville Valley, owing to the fact that the approach was level, whereas the grade of the old driveway was steep. This work was fully completed during the summer and involved the reconstruction of the slopes, the laying of new water supply and drainage system mains, as well as the adjacent footwalks.

City Hall Park.—New wrought-iron pipe rail fences were erected enclosing all of the plots in this park.

Broadway Parks.—Work was begun improving these small parks between Fifty-ninth and One Hundred and Twenty-second Streets. Contracts are in force covering the work of furnishing and setting new 5-in. curbstones between Fifty-ninth and One Hundred and Tenth Streets; also for the excavation and removal of earth from the plots, and the replacing of the material with garden mold to a depth of 18 in.; paving the end of the plots with asphalt tiles, and the erection of ornamental iron railings. This work was not completed during the year.

Repairing the asphalt walk pavements in the Central and other city parks was continued during the year, the work amounting to 150 000 sq. ft. Forms of contracts, specifications, contract drawings and details were prepared for various works which will not be begun until the early part of 1909 as follows: the improvement of the sidewalks around the park at Westerleigh, Richmond; repaving, where necessary, the cement walks of the small parks in Manhattan; furnishing and erecting 3-in. pipe fences around all the plots in Tompkins Square and a picket fence around the playgrounds; regulating and grading the northerly half of John Jay Park; improving the addition to Riverside Park opposit the Grant Tomb; paving with asphalt tiles certain walks in Central and city parks; improving the entrance to the American Museum of Natural History on Seventy-seventh Street.

BRONX.

Pelham Bay Park.—A shelter pavilion and a new comfort station at the camping grounds were constructed, as well as 100 bath-houses. Seven hundred feet of water main were laid at the camping grounds. Improvements were made to the road leading to City Iland. The road from the old entrance to Hunter Iland leading northwesterly, begun in 1908, is about one-half completed, and the roadway of the Eastern Boulevard was reconstructed. The walks from the Bartow station to the City Iland bridge are being paved with hexagonal asphalt blocks. Progress was made on the drainage, begun in 1908, along the New York, New Haven & Hartford Railroad, and of the swamp lands around the athletic field. The Pelham Bay shore and bathing beaches were improved.

Van Cortlandt Park.—The Colonial garden improvement, begun in 1905, was continued, 10 000 cu. yd. of topsoil being placed at its northerly end to raise the garden 3 ft. The floor space of the golf house was increast 100% by enclosing the veranda. Progress was made laying a waterpipe for irrigating the golf links, gutters were laid along the golf links road and eighteen new tees were bilt. The path at Gun Hill road is being paved with hexagonal asphalt blocks. Five hundred trees, brought from Europe, were planted in the nursery, and about 10 000 plants were propagated there.

Bronx Park, including the Botanical and Zoological Parks.—Progress was made walling and fencing the eastern extension of the park, begun in 1908, and on the stone wall and fence separating St. John's College from the botanical garden. The concourse entrance from Pelham Avenue, and the concourse and approaches to Baird Court were completed, as was the Baird Court improvement and the granolithic sidewalks for it. A public comfort station in the Zoological Park, the elephant house, and soda pavilion, were likewise completed and the Administration Bilding, is well under way.

Crotona Park.—Work, begun in 1906, was completed on the improvements of the grounds north of the Municipal Bilding. The grand stand was rebilt and 75 ft. of telford path bilt near it. In addition paths were bilt or resurfaced, drains bilt or repaired, 5 000 ft. of new gutters laid and about 12 acres of ground filled in and graded.

Considerable filling and grading was done at McComb's Dam Park. At the Claremont Park the improvement of the Clay Avenue side, begun in 1905, was continued; 1 500 rhododendrons were planted on the slope of the hill, and many deciduous trees and shrubs along the avenue. A section in the easterly part of the park was graded and seeded, and a number of general improvements were made. The northerly section of St. Mary's Park was graded and treated with topsoil, and the lowlands in the eastern portion were filled in. The comfort bilding was overhauled and repaired, and the easterly side of the park fenced. At St. James' Park progress was made on the foundation wall and fence on the Creston Avenue and north side of the park, the wall being made to conform to the new grade of Creston Avenue.

The northern section of Echo Park was graded and seeded and new gutters laid. A bridle path was bilt along the south side of Spuyten Duyvil Parkway, and a retaining wall at its westerly end. About a mile of gutters were relaid and the westerly side of the parkway resurfaced. Riverdale Avenue was surfaced with asphaltic concrete and the roadway was sprinkled with 10 000 gal. of crude petroleum oil to render it dustless.

At Mosholu Parkway improvements were made to the glen near Webster Avenue. The old railroad bed leading to Jerome Park was filled in and macadamized. The roadway was sprinkled with 30 000 gal. of asphaltic oil. The grading of the road along the southern boundary of the Bronx and Pelham parkway was continued, and repaving and surfacing was in progress between the Southern and Eastern boulevards. Gutters were laid on both sides from Southern Boulevard to Bronx River, including the new catch basin and drains. The parkway was partially reconstructed and resurfaced.

BROOKLYN AND QUEENS.

Prospect Park.—A contract was made for repairs to and the wiring of the Soldiers' and Sailors' Memorial Arch at the Plaza. The exterior of this arch had never been repointed or treated in any way since its construction twelve years ago. The old system of lighting was inadequate and had been out of use for years. The new contract called for the complete repointing and repairing of the arch and the installation of an up-to-date system of lighting. Work is finisht at a cost of $2 961. A contract for repairs to the various stone entrances to the park, including repointing, was completed at a cost of $2 430, the work including the Main entrance, Willink entrance and the Circle entrance. The Plaza, over which a great volume of traffic enters the park, was paved with cobblestones, originally laid some thirty odd years ago. This pavement had sunk in many places to a depth of 18 in. or more, and was, not only unsafe, but decidedly unsightly. After careful study a contract was made for repaving the area with asphalt tile blocks on a concrete foundation to a readjusted grade. The work was successfully completed without any interruption of traffic across the Plaza, or into the park, at a cost of $30 307.43. Contracts were prepared and advertized for laying 2 400 ft. of 12-in. water main in Prospect Park at a cost of $4 000. A contract was made for 26 exhibition cases for the Museum of Arts and Sciences, at a cost of $7 245, the work being nearly completed.

McLaughlin Park.—Two thousand linear feet of interior fence was erected in McLaughlin Park, Brooklyn, at a cost of $2 090. This park is used principally as a playground, and the walks are enclosed by this three-rail pipe fence, the top being surmounted with spikes to prevent its use as a bench. A contract has been prepared for paving with asphalt the remainder of the roadway of this park at a cost of $1 500, and another one was prepared and advertized for the construction of a large shelter house at a cost of $60 000.

A complete examination of all the fences surrounding the larger and smaller parks of both boros was made, and it was decided to include the painting of them in one contract. This work, involving the painting of 13 miles of fence, three bridges in Forest Park and one bridge on Highland Boulevard, at a cost of $6 430, has been completed. A contract was let for the repairs to the asphalt roadways on Glenmore Avenue, Eastern Parkway extension and some walks in Prospect Park. The work was finisht at a cost $12 081. A contract was also let for 330 000 sq. ft. of asphalt tile walk in the various parks, and the work was completely finisht before the advent of cold weather, at a cost of $83 325.

A study was made of the traffic roadway of Ocean Parkway that had given the department some concern for years. From the Ocean Parkway entrance of Prospect Park to King's Highway there is a 25-ft. traffic road paved with macadam parallel with the parkway. It had been impossible to keep this pavement up in spite of the diligence of the department, and it was decided that a new and more modern pavement was necessary to meet the constantly increasing demands made by heavy wagon traffic. A contract was therefore made for paving the roadway with asphalt pavement on a concrete base, the curbing to be of bluestone. This work was finisht about November 1st, at a cost of $63 134.20.

At Sunset Park, Brooklyn, a contract was made for bilding 2 500 lin. ft. of rustic stone boundary wall at a cost of $27 943, and the work is still in progress. Contracts were let for a new tennis house in Prospect Park at a cost of $58 550, a new shelter house in Fulton Park to cost $11 000, and a new shelter house in New Lots Park to cost $6 890. These three bildings are well under way. A contract was let for grading Greenpoint Park, Brooklyn, involving the changing of a vast dump of 44 acres into a temporary athletic field. The contract required the grading of some 35 000 cu. yd. of earth and the readjustment of the railings and sidewalks. Considerable work was done and it will be continued in the spring. The contract price is $9 625.

A contract was made for a riprap foundation for a seawall along the Bay Ridge shore to extend from the foot of Sixty-seventh Street to Ft. Hamilton, a distance of 2½ miles. This required the placing of 150 000 tons of riprap stone at a cost of $90 702.91. Work was completed in October. Another contract is being prepared for a granit bridge to carry First Avenue over the shore road near Bay Ridge. The latter work will involve the changing of the grade of the driveway, and its estimated cost is $94 000.

This address, to a large extent, is a compilation of data furnisht by the engineers and others in the service, not only of the City and State, but of the public service corporations, and I desire to record my indetedness to them for their assistance. Without it this paper would have been far less complete than it is. While this demand upon their time, coming as it did at the busiest season of the year, meant much personal inconvenience to them, the information was cheerfully given. This, to my mind, is a gratifying evidence of the spirit of co-operation which animates those in charge of our great public works.

ANNUAL DINNER.

The Sixth Annual Dinner of the Society was held at the Hotel Savoy, on January 13th, 1909. There were present 410 members and guests.

This was the most successful dinner ever given by the Society. Never before has a dinner been so well attended, both by members of the Society and by so large a number of distinguisht city officials as guests. It was also a financial success.

The President, Mr. Robert Ridgway, acted as Toast Master and introduced the speakers of the evening, who were Hon. George B. McClellan, Mayor; Hon. Herman A. Metz, Controller; Hon. George Cromwell, President of the Boro of Richmond; Mr. Robert Davis, Mr. Calvin Tomkins, Mr. Merritt Smith and Mr. Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment.

During the evening a medley of college songs were sung, and also a song to the air of "Heidelberg," entitled "The Municipal Engineers," composed for the occasion by Mr. H. Lincoln Rodgers, Member of the Society.

ADDRESS OF MR. ROBERT RIDGWAY.

Members and Guests of the Society:

When this Society was started some six years ago, there were some enthusiastic ones among its organizers who predicted that its membership would eventually reach 500. In the few years that have since past we have grown to be over 600 strong, and feel we can look to the future with confidence. Our strength is indicated by your presence in such numbers to-night, at this, our Sixth Annual Dinner.

That we have increast so rapidly and substantially in numbers and influence is, in a large measure, due to the wonderful material development of the City's engineering enterprises of the last few years, but the primary cause of our strength is found in the fact that as a Society we have constantly kept before us and have been guided by the purposes for which the Society was organized, *i. e.,* to promote the material development of the City of New York, to elevate the standard of efficiency and harmonize the work of the various engineering staffs of the several departments of the public service, and to promote the technical, professional and social interests of the engineers in the employ of the City. That our efforts have met with success is well establisht. A spirit of co-operation has been promoted between the engineers of the various departments and boros, and it would be difficult to estimate the great amount of good that has come to the City thru this co-operation in the way of harmonizing the work of the several engineering organizations and cutting out unnecessary duplication of it.

The six years that we have been organized have been years of amazing engineering development. We are so occupied in dealing with our problems as they arise, that we often fail to realize what this progress has meant, but it is safe to say, I believe, that in the magnitude of work accomplisht, it surpasses anything that has occurred in a like period of the world's history. If one could go back to-night to the conditions of six years ago, it would seem like moving back a generation. As a result of the enterprising and broad-minded spirit of the community, the engineering activity of the world is now focust in this City, and when we reflect on what has been accomplisht here and on the prospect of still greater progress in the near future, we are justly proud of our citizenship in this imperial city.

It is a significant fact that the birth of the Society is practically coincident with the beginning of the present City administration, and the material advance made by our City in the past few years is due, in large measure, to the far-sighted policy the administration has pursued. It is not necessary here to enumerate the large public works that have been inaugurated or completed in this time, as they are familiar to you. Among the most notable are the opening of the rapid transit subway, and the beginning of work on the scheme for the much needed enlargement of the City's supply of pure water. This latter project, made possible by laws suggested by the present Mayor, and well begun by the Board appointed by him, is, of the engineering works now in progress, approacht in magnitude only by the Panama Canal, and its successful completion will be one of the great achievements of this generation. I might also mention the putting into operation recently of the high pressure fire service, which has won deserved praise from the press and from all who have had the privilege of observing its successful working.

This being a Society of Municipal Engineers, it is fitting that we should be honored to-night by the presence of the Mayor, who has probably done more than any of his predecessors to place the engineer in the position where he belongs, and to recognize that not only is he a technical man, but in many cases a good executiv as well.

I take great pleasure in introducing Mayor McClellan.

ADDRESS OF HON. GEORGE B. McCLELLAN.

Mr. President and Gentlemen:

It is an old saying, as it is a trite one, that the age in which we live is one of advertizement, and a great many men believe that to succede they must advertize. Not only is this true in the ordinary business, but it is true in many of the professions. Some lawyers, physicians, architects, and even artists believe that if the public is to come to them, they must first go to the public; that if they are to get the confidence of the public they must first proclaim the fact that they are worthy of it. Some of my fellow-lawyers have been known to prefer reading notices to reading law; some soldiers and sailors even have been known to prefer subscribing to clipping bureaus than subscribing to the articles of war. There is, however, one profession that in this respect has not been abreast of the times, and that is the profession to which you have the honor to belong. Without advertizement, without self-exploitation, the engineers of this country have obtained and retained the confidence of the public, so that they occupy to-day a position in the affections of their countrymen side by side with our soldiers and our sailors. Just as "Uncle Sam's man" is synonymous with "officer and gentleman," so "engineer" means "honest man." The reason for this is obvious. The competition has been so great that most of our engineering schools are excellent. The old saying does not apply to them, "Better to have gone and loafed than never to have gone at all," because loafing and engineering are not compatible. "He who goes and goes to play, does not return another day." No man becomes an engineer unless he knows his business; no man remains an engineer unless he cares for his business. The work is hard, the compensation small, the life is one of sacrifice.

I am very proud, gentlemen, to be the official head of such a body as this, which is a triumphant vindication of the doctrine of the survival of the fittest. A skyscraper may be beautiful or it may not; it depends upon your point of view and it depends upon the architect, but the fact remains that the skyscraper is the embodiment of modern 20th century development, and yet the skyscraper could not exist but for the foundations which no one sees and very few people know anything about. Our modern progress would not be what it is but for the work that has been done and is being done by the engineers of the United States. The City owes you a debt very difficult to pay. Anyone who is familiar with the proceedings of the Board of Estimate knows the amount of positiv constructive work that is due to the ability of its engineer, Mr. Nelson P. Lewis, but very few know the millions of dollars that the taxpayers have been saved by his rugged honesty, because of the propositions that he has killed, propositions some of them visionary, some of them impracticable, some of them a great deal worse.

One of my constant and gentlest critics recently made the statement that if I had hurried municipal work, if I had kept the municipal engineers up to the jobs, I should have saved the City a great many millions of dollars. Now, this gentleman critic of mine did not know what he was talking about. One of the handicaps from which the City suffers, and from which private enterprise is free, is litigation. It is a safe rule to follow, in estimating the time necessary for public construction, to allow 50% additional for lawsuits, so as to give ample opportunity to disappointed contractors, disgruntled property owners and more or less public-spirited taxpayers to bring their actions for the purpose of either delaying the work or stopping it altogether. In any event, if this were not so, municipal work could be concluded quite as rapidly as private work. The delay comes because of the love our people have for the law and the delight they have in seeing it in operation, and is not chargeable at the door of the City's engineers.

To my mind the most remarkable example of the efficiency of municipal engineering was the way in which Mr. J. Waldo Smith, with the help of Mr. Ridgway, Mr. Davis, Mr. Merritt Smith and Mr. Flinn, organized, in less than a year, out of absolutely nothing, one of the most efficient engineering forces in the United States. If that great and absolutely vital work is brought to a speedy and an honest conclusion, as I most firmly believe it will be, it will be because of the ability, the earnestness and the energy of the engineering force directed and presided over by President Bensel, who has absolutely disproved the old theory that an engineer cannot be a magnificent executiv officer. This is one of the show-works of the Municipal Engineers, and yet, admirable as it is, it only excedes in quantity what is being done day in and day out, year in and year out, in every department of the City government by engineers whose very names are not known in the newspaper offices, who work harder than almost any other officials in the City government, who ask no thanks and get none, who, when they make mistakes, are ferociously criticised, and when they do well, receive no praise for it.

I have a theory that the great, lasting progress of civilization and mankind is not brought about by the solitary individual acts of great men, but by the united endeavor, the union of purpose, of ambition, and of hope, of the small men. I believe that this world of ours would not be what it is had it not been for the sterling sense of duty among the rank and file of the armies of mankind; and after all, there is a great satisfaction and a great reward for those who serve this City of ours. Those of us who care for her know that just as surely as we are in this room to-night, in God's good time and in God's own way, she will be the greatest and the best of all cities of the earth, provided, only, we do our duty, and if we do our duty according to the opportunity and the light that God has given us, so we shall have our reward, for we can feel that in our way, whether it has been great or small, we have helpt New York to fulfill her manifest destiny.

Mr. Robert Ridgway.—You all know that when the engineer, after working a year or more on it, presents his plan of a great bridge, a subway, or a canal, the editor tells him the next morning that he is all wrong and points out how the problem should be treated. We bow with submission to the omniscience of the Press, but occasionally wonder at the mysterious workings of the Providence that placed all the wisdom of the world in the heads of the editors. Like the peace of God, it passeth our understanding. Mr. Davis has kindly consented to lift the veil a little way for us to-night and enlighten our ignorance on the subject. I take pleasure in introducing him to you.

ADDRESS OF MR. ROBERT DAVIS.

MR. PRESIDENT AND GENTLEMEN:

I do not know who arranged the program and put down opposit my name the toast, "The Infallible Press," but it shows structural weakness in the engineering end, because I think the "Infallible Press" is very much like the "Indestructible fireproof bilding,"—it is not. I have had a little experience, from California to the Atlantic seaboard, in newspaper affairs and don't know of any newspaper that is infallible. I knew of one that was infallible for three years, but they had a recount and then it was not.

(After several amusing stories illustrating the lack of infallibility of the press, Mr. Davis continued as follows:)

I have explained the infallible press, but, seriously, gentlemen, the engineers ought to have something said to them about an absent one. The engineers in the living, who erect bridges and throw spans across the streams and connect towns and cities and put up telegraf poles that we can pull ourselves home on, are of more or less importance, but I want to recall to your mind a great engineer, and one who did more than any of you have done, and more, I hope, than you will ever do. It was not very long ago when a little engineer, "Little Mac," devised a plan to throw a bridge across Mason and Dixon's Line, over which an army crosst. That was an engineering feat which saved the country; that was a piece of ingenuity that no man can gainsay and no one forget, and I desire to drink the health of the absent father of the present Mayor, in silence.

MR. ROBERT RIDGWAY.—We had hoped to have Boro President Ahearn here with us this evening to speak on that City where many of us used to dwell and which is now fast becoming a memory. "Little old New York." He finds himself unable to be here, but sends this letter, which I will read:

"JANUARY 11TH, 1909.

MR. ROBERT RIDGWAY,
President Municipal Engineers,
City of New York.

MY DEAR MR. RIDGWAY:

I have the honor to acknowledge receipt of your very kind invitation to attend the Sixth Annual Dinner of the Municipal Engineers of the City of New York, to be held at the Hotel Savoy on Wednesday, January 13th, 1909, and to supplement my former statement that I would make every effort to be with you on this occasion.

I find now that I had, prior to the receipt of your invitation, made an engagement for that evening which it will be impossible to forego.

I appreciate more than I can say in words the honor you propose to do me in asking me to respond to the toast "Manhattan," and if I were able to be present I would endeavor to convey to you some of the ideas which have been forced upon me as the result of my administration of the office of Manhattan's Presidency.

In many minds the impression seems deeply seated that Manhattan is settled, and that but little opportunity is given for its further improvement and development. With that idea in mind much of the money in recent years which has been appropriated for public improvement and the development of the City of New York has been spent in outlying boros. While I have no objection to this, I think it but fair to direct your attention to the fact that there is much need of development in Manhattan, and from the standpoint of Manhattan's present and future welfare much should have been allowed to remain here.

Generally, the objection seems to have been a financial one. The cost of improvements in Manhattan, involving as it does the condemnation of property which has become excedingly valuable, must be very great, but the immediate return to the City in the enhanced value of the property benefitted by the improvement is the best answer to that objection.

There is no question that property for additional streets, lengthwise and crosswise, in the Boro of Manhattan, should be taken. The congestion of business in the lower part of Manhattan devoted to wholesale business is one that must soon be met and only by providing for new streets can it be settled. The location of these proposed streets, the manner of their construction, their width, and generally all that pertains to their physical construction is one that comes within the purview of the engineering force of Manhattan and can be dealt with and met by it.

I wish only to emphasize that Manhattan is not settled and must not be regarded as finisht, and that in none of the other boros more or to a greater extent than in the Boro of Manhattan should a larger percentage of the money raised by taxation be applied in the way of improvement and development. Surely generous provision should be made for the great and growing northern and northwestern section of Manhattan along the line of the present Subway and its extension.

In all of this, however, I do not wish to discriminate against that which properly belongs to the other boros, but I know it will not be regarded as unduly selfish in behalf of Manhattan when I make these claims in behalf of the larger appropriation of expenditure in improvements therein, and in this connection would call your attention to the fact that of the total taxation of the City of New York the Boro of Manhattan for 1908 contributed 68 per cent.

The Boro of Manhattan is the gateway to the American continent. At its shores arrive millions yearly from other countries. It is a foolish and short-sighted policy to narrow or restrict the expenditure of money for the improvement and future development of Manhattan Iland, both from the standpoint of the beautiful and artistic and the utilitarian.

Among the matters which I believe are pressing are the extensions of Sixth and Seventh Avenues. Seventh Avenue, in particular, seems destined to become one of the most popular thorofares of Manhattan. It extends northerly to the end of Manhattan Iland, while southerly it winds up against a blank wall. At Thirty-third Street vast improvements have been made by private capital, for there is located the terminal of the Pennsylvania Railroad. It would seem, therefore, to be a necessity that something be done to provide an adequate outlet at its southerly end.

If these improvements which I suggest meet with the approval of the engineers, I would be glad, indeed, and would welcome whatever support they would give.

I congratulate the Municipal Engineers of the City of New York upon the success which their organization has already met with, and wish their efforts and their labors unbounded success. I can conceive of nothing but good as the outcome of their meetings to discuss engineering problems that confront the City of New York. I believe the result thereof will redound to its great glory.

With thanks for your kind remembrance of me, I beg to remain,

Respectfully yours,

JOHN F. AHEARN."

MR. ROBERT RIDGWAY.—Several years ago the pastoral beauties of Richmond were pointed out to us by the President of that boro, and emphasis was laid on its advantages for suburban residences. A year or so later, while still retaining its old charm, it had grown so wonderfully that we hardly recognized it. Last year the Manhattanites began to tremble for the supremacy of their boro as the metropolitan center, and lookt apprehensivly to the future. One of the reasons we are here in such numbers to-night is to learn just what great strides Richmond has made in the past twelve months, and the Boro President has come here, at a personal sacrifice, to inform us on this point.

I take pleasure in introducing to you Boro President Cromwell.

ADDRESS OF HON. GEORGE CROMWELL.

MR. PRESIDENT AND BROTHER ENGINEERS:

It is a very great satisfaction to us who live in the center of the City to observe its constant growth. Last year we came here and we listened to a very extended argument, clearly and almost conclusivly indicating that the Boro of The Bronx had extended its jurisdiction way down, as I remember it, into darkest Africa. The constant acquisition of territory and influence that was observed by the activities of the people in The Bronx was held out to us little fellows in the younger and growing boros is a constant example of encouragement as to what might possibly happen to us. I was very anxious to talk with the President of the Boro of The Bronx after that meeting, having heard he had acquired Egypt and other parts of the other hemisphere, because we were just at that time,—as you engineers will perhaps remember—advertizing for a large reinforced concrete retaining wall at the gateway of the Boro of

Richmond, and if it had not been for the fact that we had already prepared our specifications and were about to let the contract, I would have askt Brother Haffen, thru his distinguisht and eminent Commissioner of Public Works, if we could not add a pyramid or two; that would have been the glory and wonder of the City of New York forever. Unfortunately, we were too late.

To-night we have heard, I am sorry to say, of the diminishing Boro of Manhattan, in a very interesting address, telling of the trials of that constantly smaller-growing boro, and we of Richmond want to stretch out to you a helping hand and to suggest to you that there is an abundance of room down there in Staten Iland to which you can all come.

The Boro of Richmond is really the greatest heritage, but what we want to do is to bring it closer and into more absolute touch with the centers of the City. We have a wonderful territory down there, the greatest the world ever made, and I would be very glad to tell you the real facts. All we need down there is to attach the Boro of Richmond a little closer to the main centers of business. Instead of encouraging the bilding of tunnels to lead people out into New Jersey to live and pay their taxes there, to go up beyond The Bronx into upper Westchester and pay their taxes there, out into Nassau and Suffolk Counties, using the City's money to take the people away from the City of New York, why in the world, gentlemen, with the small-expenditure of a few odd million dollars, don't you attach the Boro of Richmond more closely to these business centers and encourage everybody to go down into the Boro of Richmond and live there, and incidentally pay their taxes there.

You talk about the expense of the ferry. Isn't it a great expense to maintain the bridges? Or is it not wise for the people of this great City to pay a little money in order that we may get nearer to the great Boro of Richmond, and enable the people of this City to go down and have comparativly cheap homes, and come nearer and nearer to the centers of business in New York and make the City great? I think it is a great mistake for us to encourage people to go outside of the City.

But, seriously speaking, gentlemen, I want to absolutely corroborate what one of the speakers that has preceded me said a little while ago. The great success, if we have had any great success, and

I believe we have had in the Boro of Richmond, is because we have put into the hands of the engineers a large and controlling part of our work. Some one said—I have forgotten whether it was the President or the Mayor—that the executiv ability of certain engineers was remarkable. The great success we have had in our administration in Richmond has been due to the fact—and I want to say it because they are members here of your Society—that the engineers who are in charge and in control of our affairs in Richmond are among the most executiv and best that I know, and the success of our Boro of Richmond is not due to the head of the office, it is due to the fact that he has had the most hearty and splendid cooperation and support of the engineers that were under him, and I hope that in all the boros, those little outlying boros like Manhattan, The Bronx, Queens and Brooklyn, will follow our example and rely upon their engineers, and they will find that their boros will grow, and if they follow in the lead of Richmond we will be the greatest City in the world.

Mr. Robert Ridgway.—I have a telegram from Mr. Charles R. Lamb, who was to be a guest of the Society, which I will read:

"Regret illness prevents my attendance. Extend best wishes to Society for a prosperous year.

Chas. R. Lamb."

The next speaker hardly needs an introduction to this Society. He has been with us at several of our dinners and has always given us some excellent thoughts to carry away with us. Mr. Calvin Tomkins will address us on a subject that is in the mind of every intelligent New Yorker, "The future development of our City."

ADDRESS OF MR. CALVIN TOMKINS.

Mr. President, and Gentlemen of the Municipal Engineers:

The first time I had the pleasure of addressing you, some four or five years since, I believe, there were a number of private citizens at the guests table—Mr. Lewis presiding—and there were several Commissioners of Departments of the City of New York. The next time I had the pleasure of being present there were fewer private citizens and there were several Boro Presidents present in addition to the Commissioners. This year, gentlemen, we have the government of the City of New York with us, the Mayor, the Comptroller, the President of the Board of Aldermen and the five Boro Presidents. Now, that is as it should be. That, to my mind, is illustrativ more than anything else can be, of the growth and of the influence of this great organization of Municipal Engineers in the City of New York. I hope the time will come (it has already arrived in German cities) when the officials of the City of New York will be the technical men, who conduct its affairs. The Mayor is here this evening. His Honor is the official head of the government of the City of New York. He occupies the position of a coign of great vantage. What he says is authoritativ. His honorable position commands respect and commands universal attention thruout the City.

In addition to the Mayor, you have myself and one other private citizen. I may be taken, perhaps, to occupy the position which in England is known as "His Majesty's opposition"; or, going back to the old days of Goethe, I occupy the place of the spirit Mephistopheles, the spirit which really finds fault more or less with everything. It is representativ, more or less, of the public spirit of the City of New York, expressiv of the discontent, of the aspirations, of the wishes of the City for better things. No government can give us the things that we want. It is only an aspiration; it is a hope, and we represent that hope. I hope you will always find room for at least one or two private citizens at your assemblage to represent more or less the wish of the people of New York for things that possibly are not possible of immediate attainment, but which are ideals toward which we should strive.

Now, gentlemen, you are virtually the *de facto* government of the City of New York. As I have said, I hope some time you will become the official government of the City of New York. Cities are virtually business organizations. Their conduct is not based on the political organization which voices the development of the country at large; they are business aggregations and the large cities of the world are essentially modern organizations. I have been surprized recently in reading a very interesting work by Mr. Sydney Webb, an Englishman, to see how very recently indeed the City and the City government has developt. It is less than a hundred years old. Our Municipal Government, which we inherited from England, is really the Old Church Government imposed upon the English communities thru the parish by the Kings, and at the beginning of this century it is practically broken down in England. Between 1828 and 1835 they revised their Municipal Government there, but we have that problem yet before us. We are working under the forms of old town organizations, which antedated the municipalities in their present schemes, and the machinery which we are utilizing is entirely inadequate to the demands. Germany stands in the lead and the German cities are actually governed by a body of technical men, mainly engineers, and lead the world in municipal development.

His Honor, the Mayor, has stated the problem. It is not the concrete problem which we have before us here; it is how to try to fulfill the manifest destiny of the City of New York, *i. e.*, how to adapt the City to its best uses. That is essentially a technical problem and not a problem of politics, and it cannot be solved by politics. The difficulty with the situation is, we have largely lost in our cities the initiativ for local self-government; the business problem has taken the place of the old political problem and we have not adapted ourselves to the new conditions which have arisen. The urgent requirements of the City for all sorts of utilities are far beyond the modern capacity of the City to supply.

I will read here a few extracts from a recent communication of Mr. Purdy, Tax Commissioner of the City of New York. He says, in an article on the growth of Municipal expenditures, by Prof. Gebhardt:

"During the past 40 years the population of England and Wales has grown 50% and the expenditures have increast 300%." So we need not be unduly staggered by our great increase of expense. "In Belgium the population has increast 25% in 7 years and expenditures 100 per cent. In France, from 1836 to 1899, the municipal population increast 16%, while the municipal expenditures increast 600 per cent." Prof. Gebhardt says, "Of the 13 largest cities in the United States, exclusiv of New York, from 1890 to 1903 their population has increast 41% and their expenditures 106 per cent."

The central truth of all this is that in the great cities of this country and in the Old World as well, Town Government has given place to City Government. The City of New York itself in the last ten years has been substituting modern City Government for Town Government, with all its attendant cost, and this is part of the price we have paid for consolidating three cities, 20 villages and almost 100 separate governing bodies, and to a greater or less extent we have been extending all the City conveniences to these many country towns.

Gentlemen, that is the underlying cause of the enormous expansion of our det here in the City of New York, and I think it is characteristic not only of this City, but of all great cities of the world. Great cities have been made possible by transportation; transportation of food, transportation of commodities and raw materials to the City, and the convenience of working these up. The advantages of living together have brought people together and large cities are bound to grow and not to diminish in size, providing we can supply the skill for engineering them in accordance with the progress of the world, and that we must do; there is no backward step; we simply must find a way of doing it; we must adapt our political institutions to our social and commercial situation.

I have a great deal of sympathy for the City officials. I believe, while the honor is great, the responsibilities are also very great, and the impossibility of providing what the City wants causes the men who are chosen to those offices to occupy a comparativly thankless and certainly a very difficult position. I know myself, I have repeatedly gone before the Board of Estimate and Apportionment, Mr. Lewis can bear me out, and urged specific improvements, when possibly those special improvements might not be the ones that the City should undertake at that time. It is the duty of private citizens; it is the manifest duty of people in localities to ask for and press for the improvements that they locally demand and that they think the City-at-large requires, but it is the responsibility, the honorable and serious responsibility of the government of the City of New York, *i. e.*, the Board of Estimate and Apportionment, to determin which improvement shall have precedence, to determin the sequence in those improvements, and that, gentlemen, is not a pleasant responsibility, however important and serious it may be.

Our City organization is complicated by many things. In the first instance, we have the national complication, the division of the country into two great parties. These parties exist in every City. In Philadelphia and in most of the western cities the dominant party is Republican. In New York City it is Democratic; and the party lines of cleavage have no reference whatever to local questions, which should be first in the minds of the people. Then we have the problem of State influence. In the State of New York we have two City Governments for New York City, the Government which is located at the City Hall, and the Government which is located at the Capitol in Albany. All important matters are past upon at Albany. Many of the questions of routine government and subsidiary matters are past upon here by the government of the City of New York, and until such time as we can obtain a larger degree of home rule in our cities, which shall relieve the Legislature of duties which it should not and cannot effectivly perform, not knowing the local situation, we must expect great complications, great additional expense, and a serious handicap.

Then, in addition, we have the problem of the rich and the poor. The well-to-do part of the community in the City of New York is a comparativly small part of that community. We have an annual accession of many thousands of people entirely unaccustomed and unacquainted with governmental conditions in this country and utterly unacquainted with government conditions productiv of the best results in the City of New York; brought to us from Europe every year, and the problem of assimilating and making good citizens of this great aggregation of foreners is another handicap we have to meet.

Then, in addition, gentlemen,—I am not one of those men who believe that the real trouble is with the ignorant forener—the great difficulty with the City of New York and with every municipality in the United States, is the interest of the old-time Americans and the men of property and of influence in the community in exploiting the needs of the people of the City. That is a serious hindrance we have to contend with; it outweighs all questions of State, National, foren and financial difficulties, and until we can develop a higher public sentiment, a higher public spirit among the people, the older people, the people who own property in the City of New York, we cannot expect to attain a decent and advantageous government.

I shall not dwell at length upon the causes which have made New York the great City that it is, and which will, probably within the lifetime of most of those here present, make it the greatest City in the world. The Department of Commerce recently publisht a railroad map of the world and a glance at that map indicates the strategic position which the City of New York occupies. You see a net-work of railroads in Europe; you see a net-work of railroads in North America. Those railroads center at various European ports in the East, and all center here at the Port of New York on the West. The Port of New York is the point of exchange for the water-borne commerce of the world, with the rail-borne commerce of North America; and that is the underlying fact which, in spite of all the lack of public spirit, of all the mistakes we may make, will, within a comparativly short period of time, put New York in the position of the leading City of the world in population and financial interest. It rests with us to make it a center of civilization and a tool of commerce adequate to the opportunities which are inevitably coming to us.

I believe that the City of New York must, as it develops, live upon itself. That is the only source of sustaining power that exists in the City for carrying on its improvements, commensurate with the great opportunities which are coming to it. Values depend primarily upon numbers, and as numbers increase, numbers of population, the values in the City will increase; and one of the great problems which confronts us is to safeguard and hold for the City a part at least of this great aggregation of property which is being bilt up simply by the numbers of people who come to live in the City of New York. Of that property we can only reserve, under the legal restrictions which are placed upon us, 2% of the valuations annually, for conducting the government of the City of New York, and of that 2% we do not get all, because the valuations are not full valuations. Under the Low administration a beginning was made to tax property at its full value and great strides were made, and in the older and central parts of the City probably we do tax property pretty nearly what it actually is worth, but in the suburban districts we have not arrived at that yet, and there is a great opportunity, a great reserve of capital still awaiting our use, our utilization, on the outskirts.

The tendency is continually toward congestion, and the efforts of organizations like this body and other civic organizations, should be continually to disperse this congestion, so as to provide decent living conditions, and so as to bild up tax values in the outskirts in order that the City may utilize those tax values for its future growth and progress. Next to manufacturing I believe that the most profitable business in the City of New York at the present time and for many years has been the exploitation of the congestion of the City itself, and that is the thing that the government of the City of New York and the popular opinion of the City of New York should contest.

Gentlemen, we have, I think, reacht the point where we are beginning to regard the transportation of the City of New York as a public matter, not any longer as a private matter. After the consolidation of the outlying boros into New York City and the successful demonstration of tunnel transit under the Hudson to New Jersey, the problem has become too vast and complicated, too much involved with social and commercial development of the City, to be longer capable of successful treatment by private enterprise without continuous, effectiv municipal control, and such control can only be exercised thru ownership, *i. e.,* thru the power of recovery if the facilities are not properly utilized.

Tax values at the center and at the circumference depend upon transportation; the possibility of reaching the center conveniently, the possibility of egress from the center to the circumference alike depend upon transportation; and the limitations of private enterprise have been reacht in this matter, because private enterprise in the development of transportation is dependent essentially upon private profit, and private profit means congestion of transportation; it means intensified travel; that means, going a step further, congested living conditions; that means all of the social ills, or many of the social ills that are complained of and that we see so glaringly displayed on the East side of Manhattan and in some of our outlying districts. The past policy of the City has been for private exploitation, and, very properly, it has served us well up to the time of the tunnel service to New Jersey and up to the time of consolidation here of the five boros; but now we have reacht the end of our opportunities in that direction.

It does seem to me that the City has spent since 1903 a disproportionate amount of its capital for improvements other than transportation. $300 000 000 of det, in round figures, has been incurred by the City since that date. It spent $19 500 000 for transportation, or less than 7%, and 2½% is all we have actually appropriated within that period. We must untie the City's hands if we expect to serve the City's needs. The wealth is here. If we are prepared to adapt it and avail ourselves of private enterprise, we can do so, and the City must do it. The expansiv power of the City, gentlemen, cannot be kept within bounds. That is the one fact that I would like to have you carry away, of what I say, if you do not remember anything else. I would like to have you pass your judgment individually upon that one thought. The City of New York is bound to grow; nothing can stop the growth of the City of New York; the transportation of passengers, of freight, of gas and electricity, must be made subservient to the growth of the City of New York; and City will grow, and if private enterprise injects itself between the growth of the City and dividends, it is bound to suffer, and there is no alternativ, and the sooner that fact is recognized the sooner we will have transportation for the people, transportation for their commodities, and transportation of power.

I want simply to touch on one other thing; that is, the freight problem. Very little has been said about that. Our personal convenience has not been affected by the transportation of freight as it has been by the transportation of passengers, but the freight problem, gentlemen, the question of handling commodities is of equally vital importance to the City of New York and we must find some way of substituting for the old method of handling, by truckage here in Manhattan, the products of our factories and our mills, food and bilding materials, coal, lumber and heavy commodities, to take the place of the system which now exists. Our water front is virtually a railroad yard, given over to the storage of railroad cars, and we have no adequate terminals. We connect our factories with our docks by trucks, the most expensiv way of conveying material. The local transportation by trucks is often more than the thru transportation by railroads.

I do not intend here to take up your time by offering any solution for that problem, but I wish to call your attention to the fact that unless the City of New York devises some way of handling its freight and heavy raw materials for manufacture, it is bound to lose population and wealth, and consequently tax values, and we will lose our relativ position of advantage to the State of New Jersey, on the other side of the Hudson River. We must find some way of hauling our freight here, instead of permitting it to go over there. I believe we need a tentativ plan of growth. We have no comprehensiv plan such as German cities, and, to some extent, English cities enjoy at the present time. And in this connection I want briefly to call your attention to a very admirable paper by Mr. Lewis. This is in the nature of friendly criticism. Mr. Lewis was kind enough to send me a copy of his recent address before the City Club, and I would like to read a few selections from it.

"Many, if not all of the plans possest (that is, the plans for the development of the City of New York) merit and appeared to meet with general approval. The trouble was that they attempted to correct what were supposed to be defects in the original plan of the City, after the City had adapted itself to that plan. Corrections and adjustments of this kind are often necessary and can be made one at a time, but when a great number of such plans are seriously put forward as one scheme, and when an attempt is made to estimate their cost, the aggregate expense is such that the entire project is likely to be dismist."

I think that is good criticism, and at the same time with any comprehensiv plan we must realize that we cannot put everything thru at once, but if we had a plan toward which we could work I think it would very greatly help the situation.

"Many, if not all, of the changes which are needed and desirable in the older portions of the City, would result in substantial local benefit. If these changes are made the expense should be, in great part, assest in accordance with the benefit." Now, in that matter I do not agree with Mr. Lewis entirely, and I think that the improvements of the City of New York, these re-arrangement improvements, must be made to pay for themselves, and they can be made to pay for themselves, as they do in German cities, and as they do in London; that is, by taking land in excess of what is actually needed and then selling the land at the increast value after the improvement shall have been created. There is no limit to what we can do in the direction of reorganization of the old City of New York by adopting this common sense procedure which is availed of in the cities of the Old World.

I wish to call your attention briefly to a few extracts from another paper which I have. This came to my attention thru one of the architects of the City of New York. You know it has been suggested that we should have a Municipal Improvement Commission, a continuous commission, and I believe that is desirable, but there has been a strong tendency to make that architectural rather than engineering, or commercial in its make-up. This architect writes:

"One of the recommendations was made that an architect be made chairman of the board, or head of the department, if it were a department, and for the very excellent reason that in this country at least the architect is the only person properly qualified to lead in the larger aspects of civic improvement and development. Problems that will come before the board for solution are such as architects are constantly dealing with in the broad spirit with which such problems should be treated. Engineers in this country are not trained to consider problems in a broad way. They are, of course, absolutely essential to the composition of this board, but the function of the engineer only begins after the architect has made the preliminary studies."

I do not intend to mention any names, and this paper goes on at considerable length illustrating that idea. My own belief is, it should not be, necessarily, an architect, not necessarily be an engineer, who shall head such a body as this, or who shall constitute in its membership the predominating force, but it should be the man and the men who have the capacity to see the future of New York and bild upon foundations broad enough to meet the future requirements of the City.

In Boston the Mayor has appointed an Advisory Council, I believe of considerable numbers, and I believe that such an unpaid Council is what we need here, and I agree with Mr. Lewis in thinking it should in no wise be charged with the responsibility of determining upon or carrying out public improvements. We have the Board of Estimate and Apportionment, and the various officials which make up that body, charged with that responsibility, and they should be left with that responsibility, and all we need is an initiativ. Really, gentlemen, what we need is a development of public opinion which shall back up the Board of Estimate and Apportionment and prevent it from giving way to the pressure of private, selfish and local interests, which have heretofore very largely determined its action.

Gentlemen, in closing I want to say that I believe the engineers must break away from the old idea of private control of the conduct of the municipality if they are going to bild up the dignity and the opportunities of their profession. Our cities should ultimately be governed, and the delicate commercial and economic demands which exist require that our municipalities should be governed hereafter, by technical skilled ability and not by mere politics and popular opinion. The only way you can do that is to break the influences of private exploitation and leave the development of the City with the men who know how the City ought to be developt. The great body of voters in the City of New York, the great electorate of the City of New York, do not and necessarily cannot know. They must be brought to a position of trust in the technical ability and official opinion of the City, which should and must ultimately be directed by you, gentlemen, who constitute this organization. That is what it amounts to in the concrete. The City will grow and it is necessary that the public spirit of the City expands with its growth.

MR. ROBERT RIDGWAY.—We are going to have a few remarks from Mr. Lewis, our first President.

ADDRESS OF MR. NELSON P. LEWIS.

MR. PRESIDENT AND GENTLEMEN:

Just a word at this late hour. I congratulate you, gentlemen, upon this splendid gathering to-night. I congratulate you upon the progress of the Society from its small beginning, four or five years ago. I congratulate you that upon each recurring dinner you have had a larger representation here of the men who represent the formal government of the City which we serve, and I want to impress upon you the significance of the admirable remarks of the Mayor of the City to-night.

This has been called an engineer-ridden City. It has been said that the engineer is usurping the functions of the lawyer, of the architect, of all those men who have contributed to the great structure which we call the modern City. Some may think this true, but the Chief Executiv of the City has honored us with his presence to-night; he has been frank enough to tell you that largely in your hands rests the working out of the destiny of this great City. I am glad, too, to hear the frank admission of my friend, Mr. Tomkins, that he and the organizations for which he stands, frequently present plans which they think are admirable, but many of which they know cannot be carried out. We who see these plans in the aggregate are sometimes appalled at the vast sums which would be required to carry them out; we are staggered at the magnificent disregard of expense shown by their sponsors, and we have got to advise the governing body of the City when it is necessary to say "No," and when it is possible to say "Yes."

This is a serious responsibility. The tribute to our profession, and the recognition of our work which His Honor, the Mayor, has graciously given to-night will elate you, perhaps, but it should also sober you. Now, gentlemen, I do not ask the impossible; I do not ask you to be unreasonably sober at this stage of a successful dinner, but to-morrow, the day after, think seriously upon this responsibility which has been placed upon you and live up to it. Render loyal service to this great City and hold up the hands and contribute to the success of the administration of the Mayor who has been with us to-night.

Mr. Robert Ridgway.—It has been suggested to me that Major Smith has a few serious remarks to make.

Knowing the Major's shrinking disposition, I hesitate to call on him to come to the front, but I am afraid I will have to do so.

Mr. Merritt H. Smith.—Owing to the lateness of the hour, I am just going to say, How do you do and good-bye. I am one of those unfortunate creatures that live in the country, a commuter, and that just reminds me of a story told of the railroad upon which I travel.

A gentleman who owns the hotel right across the street from the New York Central Railroad, when introduced at a dinner by the Toastmaster, who happened to be the General Passenger Agent of that road, and after he was congratulated upon his financial success because he operated a hotel right across the way from the terminal of the greatest railroad in the world, got up and said he was willing to admit that his hotel was across the street and that part of his success in this world was due to the fact that the entrance to his bar room was right opposit the exit of the Grand Central Station, and he thought the gentlemen who operated that railroad so conducted their business as to drive their patrons to drink. He went on to say that after a man had waited up in the country somewhere for a train that was two or three hours late, meandered down over the tracks of that greatest railroad in the world, and was asphyxiated for an hour in the tunnel, when finally liberated he was looking for oblivion, and they sold it by the glass or the bottle.

I want to congratulate you upon the success of this evening and upon the growing success of this Society. One by one I occasionally see a face drop out, but the places of those who are dropping out are rapidly being taken by younger men, and I hope we live to see this gathering, this Association of Municipal Engineers the greatest Association of its kind in the greatest City of the greatest country that is known around the world.

MR. ROBERT RIDGWAY.—Before breaking up, gentlemen, I want you all to drink to the health of the House Committee, and especially to Mr. Endemann, the Chairman.

The Controller has just arrived and is going to tell us where the money comes from.

Hon. Herman A. Metz, Controller of the City of New York, among other things, said that he believed the requirements of the Civil Service should be modified so that a man who possest ability should be able to receive proper recognition therefor, and not be held back because he happened to be in some particular grade, beyond which he could not go.

In regard to the exemption of certain bonds from the det limit, he said that while he was formerly in favor of exempting such bonds as produced an income, he now thought a better method of obtaining the desired money for public improvements was to raise the allowable borrowing capacity of the City from 10% to about 14%, thereby covering all bonds except the special revenue bonds, issued for current expenses. This he considered to be the better plan because the works that are a source of income to the City to-day may not be to-morrow.

Another suggestion made by the Controller was that the water from the river be used in the high pressure fire service mains for toilets and other purposes, thereby saving millions of gallons of Croton water. This, he said, could be easily done, as in some foren cities, by a double system of pipes, and the cost of installation would be more than paid for by the saving obtained.

BROOKLYN SUBWAY EXTENSION.

INSPECTED BY THE SOCIETY MARCH 28TH, 1908.

For this inspection about twenty members of the Society assembled at the Hoyt Street station on Fulton Street, from which point they walkt underground thru the work to the end of the road at Atlantic Avenue.

The Brooklyn subway forms an extension of the Manhattan subway system, and is joined to the latter by means of the East River tunnel at South Ferry. The extension as far as Boro Hall has been in operation since early in January of this year, and had been covered in previous visits of the Society.

The subway was originally designed and let for construction as a two- and three-track structure. Work began on this basis in April, 1904. In June, 1905, however, the construction was modified for an enlargement to a four-track structure, with deprest track spurs for connections to future subway extensions. Thus considerable portions of the subway run at two levels to avoid crossings at grade. Generally speaking, there are two tracks in Joralemon Street, four in Fulton Street, and five in Flatbush Avenue. The total length of this section is 5 770 ft., accommodating 24 500 lin. ft. of track.

The structure is of concrete, reinforced in roof and walls with square steel rods, except that steel girders are used for the longer spans at stations and at points of concentrated loading from the elevated railway structure which had to be supported in Fulton Street and Flatbush Avenue.

The total cost of the work from Clinton Street to Atlantic Avenue will be about $4 200 000. Cranford & McNamee are the subcontractors. The structure required nearly 400 000 cu. yd. of excavation, and contains 75 000 cu. yd. of concrete and 9 000 tons of steel. In connection with the work it was necessary to underpin 66 bildings and permanently support 194 elevated railway colums on the roof.

NEPTUNE WATER METER WORKS.

INSPECTED BY THE SOCIETY MAY 2D, 1908.

The second visit of inspection was made to the Neptune Wa Meter Works in Long Iland City, where the Society was treat with great curtesy by Messrs. Burton and Gamon, of the compa About seventy-five members were present.

The works are in a large brick bilding at 195 Jackson Ave All sizes of water meters up to 16 in. are made. Their man-facture calls for great care and accuracy of workmanship, since a meters are required to register within 2% of absolute correctness.

Included in the plant is a well-equipt brass foundry, which i said to be one of the best in the country, as well as many specia machines, some of which were made at the works.

HUDSON TERMINAL BILDINGS.

INSPECTED BY THE SOCIETY JUNE 6TH, 1908.

Thru the curtesy of Messrs. Jacobs and Davies, the engineers, about seventy members inspected the lower portion of th new bildings on Church Street, between Cortlandt and Fult Streets, which will serve as a terminal station for the tunnels no under construction to Jersey City.

In excavating for the site a series of fifty-four rectangular reinforced concrete caissons, each about 8½ by 30 ft., were sunk around the entire exterior. These caissons form a continuous watertigh dam, extending down to rock, about 80 ft. below the curb level, t form an efficient seal. In order to place the exterior colum footings at their required level, on either rock or hardpan before completing the excavation, 148 circular wooden stave caissons, each 12 ft. in diameter, were sunk at the same time as those in the exterior wall. As many as twenty-two caissons were sunk at one time. Ninety-seven of the interior caissons were sunk to an average depth of 45 ft. within 60 days. One of the exterior caissons penetrated 46 ft. of quicksand and 16 ft. of hardpan in 11 days.

The basement excavation was carried thru quicksand down to hardpan, and at one point to rock, 20 ft. lower, or 76 ft. below the street level, and 59 ft. below the ground water level. Before placing the bottom concrete a system of tile underdrains was laid in a bed of cinders and connected with a sump, from which the water is removed by automatic ejectors. The leakage is almost inappreciable.

The station measures about 210 by 435 ft. in plan. The excavation for the substructure amounted to 170 000 cu. yd., of which nearly a third, consisting largely of quicksand, was removed under comprest air.

MANHATTAN BRIDGE.

INSPECTED BY THE SOCIETY SEPTEMBER 26TH, 1908.

About ninety members of the Society assembled at the Manhattan anchorage for this inspection and walkt to Brooklyn across the temporary footway under the cables.

Four footbridges, serving as working platforms for the four cables, were constructed. Each is suspended from a set of four 1¾-in. wire ropes reaching from anchorage to anchorage. By August 10th, 1908, all preliminary work necessary to string the cables was accomplisht, and the first wire was started across the river. This part of the work is expected to occupy about 4½ months.

The hauling machinery is located on the Brooklyn anchorage. The hauling rope for each cable is continuous, with a wheel carrying a bight of wire at each anchorage. The hauling rope is ⅞ in. diameter, driven by an electric motor. When the motor is started, the wheel rigidly attacht to the hauling rope starts from the Manhattan anchorage, and a corresponding wheel from the Brooklyn anchorage. Each wheel carries a bight of wire, so that at every haul four wires are strung. As soon as the wheels reach their destination, the opposit anchorage, the bight of wire is taken off and placed over the strand shoe, and the wires are at once adjusted to proper position over the river. In the meantime another bight of wire is placed over each wheel and the process is repeated.

On many days over 200 wires in each cable, or 800 altogether, weighing 130 tons, were adjusted to exact position. There are 37 888 wires in each cable, and the cable will weigh about 6 250 tons when completed. The distance between anchorages is about 3 000 ft. The wire is delivered on reels of about 80 000 lin. ft. in spliced lengths of 3 200 ft. All power is furnisht by electric motors.

CROTON FALLS RESERVOIR.

Inspected by the Society October 17th, 1908.

This excursion, the largest the Society has ever had, was made on the invitation of the Croton Falls Construction Co. and the Aqueduct Commissioners, and was attended by about 350, including the members of the Society and their guests, among whom were many ladies. A special train of six cars conveyed the party to the site, where two construction trains were provided to transport them about the work.

The work consists of the Main Dam, which is being bilt on the West Branch of the Croton River, the Diverting Dam, on the East Branch of the river, and the Connecting Channel which will carry most of the waters of the East Branch to the reservoir formed by the Main Dam.

The Main Dam is of cyclopean masonry faced with concrete blocks. It is founded on rock at about 60 ft. below the original ground surface. When completed it will be 167 ft. high, about 125 ft. wide at the base and about 1 070 ft. long. The top will be 23 ft. in width, over which a highway will pass crossing the spillway by a reinforced concrete arch of 85-ft. span.

The spillway is located in the hillside at the southeasterly end of the dam, and is 700 ft. in length. Its crest will be at elevation 310. The northwesterly end of the dam terminates in a core wall bilt on solid rock and extends into the hillside. On the up-stream face of the dam is a gate chamber from which three 48-in. pipes run thru the dam to another gate chamber on the down-stream side, where they empty into a reinforced concrete condit about 90 ft. long, extending to a semicircular fountain basin, 70 ft. in diameter.

The Main Dam will contain about 240 000 cu. yd. of cyclopean masonry and 28 000 cu. yd. of concrete blocks. The concrete is composed of 1 part cement to 9 parts sand and broken stone, and the cyclopean masonry is expected to contain 40% of large stones. The concrete facing blocks are cast in wooden forms having a metal surface for the exposed face, and are required to set at least 3 months before being used. The largest blocks are about 3½ by 3 by 8 ft. and weigh about 6 tons.

The Diverting Dam will be made of earth with a cyclopean masonry core wall 5 ft. wide on top and extending to bed rock. It will be 1 183 ft. long and 54 ft. high above the present ground surface, below which the core wall extends to a maximum depth of 42 ft. The up-stream slope will be 2 to 1, and will be protected by 24 in. of paving; the down-stream slope will carry a highway, which will cross the spillway channel by a reinforced concrete arch of 80-ft. span. Two 30-in. cast-iron pipes pass thru the dam to a gate chamber and fountain on the down-stream side, thru which part of the flow of the river will be continually past for the use of the mills below. The spillway will be located along the easterly side of the valley and will be 1 000 ft. long. Its crest will be at elevation 310.

The Connecting Channel extends from the westerly end of the Diverting Dam to the main reservoir. The channel is 3 800 ft. in length, with a maximum cut of about 65 ft. Where in rock it has a bottom width of 24 ft., with side slopes of ¼ to 1; in earth the minimum width is 15 ft., with side slopes of 1½ to 1, protected by heavy paving laid on a bed of crusht stone. A controlling house will be bilt on this channel, near its up-stream end, to regulate the flow of water.

The main reservoir will have an area of 1.67 sq. miles, and a capacity of 14 192 million gallons. The diverting basin will have an area of 0.24 sq. mile and a capacity of 891 million gallons.

The contract was awarded August 23d, 1906, at a total price of $3 028 000, based on estimated quantities. These include 632 000 cu. yd. earth excavation, 250 00 cu. yd. rock excavation, 20 000 cu. yd. concrete masonry, 252 000 cu. yd. cyclopean masonry, and 28 000 cu. yd. of concrete blocks.

PENNSYLVANIA EAST RIVER TUNNELS.

INSPECTED BY THE SOCIETY DECEMBER 5TH, 1908.

The tunnels were bilt in two pairs of tubes from shafts at the foot of East Thirty-second and East Thirty-third Streets, Manhattan, to shafts just west of Front Street and south of the Thirty-fourth Street ferry terminus in Long Iland City.

The shafts were sunk as steel caissons, each crossing two tunnel lines. Openings were formed in the sides of the caissons for the tunnels to pass thru, and these were closed during the sinking. On the Manhattan side it was found unnecessary to sink the caissons to full depth, as rock of satisfactory character was found above the tunnel level. The sinking was therefore stopt, the openings for the tunnels closed solidly with concrete, and the excavation continued to the required depth in open air. On the Long Iland side the caissons were sunk under compresst air to the full depth.

The tunnels were driven with shields, in comprest air. Each tunnel is 23 ft. exterior diameter and has a cast-iron shell weighing 9 100 lb. per lin. ft., bilt in rings 2 ft. 6 in. wide. The thickness of the metal at the center of the castings is 1½ in., increasing to 2⅜ in. at the root of the flanges which are 11 in. deep. The tunnel has a heavy concrete lining, the arch being nominally 2 ft. thick from the outside of the cast-iron to the interior face of the concrete. The lower portion of the finisht tunnel is trough-shaped, the width of the trough being about 1 ft. greater than an ordinary Pullman car. This feature was devised by the late Mr. A. J. Cassatt, President of the Pennsylvania Railroad, and is expected to reduce risk in case of derailment. Ducts for electric cables are bilt into the sides of the trough, each tunnel having 15 ducts for high-tension wires and 40 ducts for low-tension wires.

Going eastward from Manhattan the tunnels have a descending grade of 1.5% to the lowest point, about 1 000 ft. from the First Avenue shafts; the first 300 ft. being on curves of 1° 30′; thence eastward the lines are tangents to points east of Front Street. From the low points the lines have an ascending grade of 0.7% to the bulkhead line about 600 ft. from the Front Street shafts. From the bulkhead line the grade varies between 1.22% and 1.9%, the steeper grade being required to permit one of the lines crossing one of the others farther east.

The tunnels were driven from both ends, the four tunnels requiring eight shields. Each shield with its machinery weighed about 270 tons and was moved by 27 hydraulic jacks, each 9 inches in diameter and 33-in. stroke. A push of 5 600 tons has been applied to a shield, but under ordinary circumstances 3 000 to 4 000 tons were sufficient. The capacity of the comprest air plant was 80 000 cu. ft. of free air per minute. This was sufficient for the supply of all headings, ten in number, two east of Front Street, except on a few occasions in the earlier part of the work. The escape of air was reduced and the work of tunneling much facilitated by the use of a heavy clay blanket on the river bed over the tunnel lines. The lowest points of the tunnels were 91.4 ft. below mean high tide, corresponding to an air pressure of 40.6 lb. per sq. in., but in driving the tunnels an air pressure balancing the water pressure at the tunnel axis was usually sufficient.

The headings from the opposit sides of the river met in February and March, 1908, at the east face of the reef which extends downstream from Blackwell's Iland, with an average discrepancy of 0.021 ft. in alignment and 0.025 ft. in levels, with maxima of 0.03 ft. and 0.034 ft. The discrepancy in the distance across the river, compared with the distance computed from the triangulations has not yet been precisely ascertained, but is about 0.07 ft.

The aggregate length of the four tunnels between shafts is 15 668 ft., an average of 3 917 ft. for each. For nearly one-half the distance the tunnel is wholly or partly in rock in which the daily progress was 2 to 4 ft. in each heading; in the remaining distance in earth, much of it quicksand, the daily rate increast from about 1 ft. per day in the beginning to an average of 9 or 10 ft. toward the close.

The iron-lined tunnels extend eastward from the Front Street shafts about 1 980 ft., the aggregate length of iron-lined tunnels east of First Avenue being 23 592 ft. The tunnels, as well as the permanent shafts, were bilt by S. Pearson & Son, Inc., as contractors.

MEMOIRS OF DECEASED MEMBERS.

OTHNIEL FOSTER NICHOLS.

The shock which is invariably felt at the tidings of the death of an activ man in full health and vigor was experienced by the many friends of Othniel Foster Nichols when they learned that his life had gone out instantly and without warning in the early morning of February 4, 1908, at his home, No. 42 Gates Avenue, Brooklyn, New York. All the day before he had been activly engaged in his professional duties at the Department of Bridges, had lunched with a group of his friends at the "Engineers' Table" at the Astor House, when he was as jovial and affable as was his wont.

Mr. Nichols was one of the charter members of the Municipal Engineers of the City of New York, was its first vice-president and was always activ in its affairs.

He was descended from Rhode Iland families which had taken a prominent and patriotic part in the affairs of the State, and whose ancestors settled in the Rhode Iland Colony early in the seventeenth century. The son of Thomas Pitman and Lydia Foster Nichols, he was born at Newport, Rhode Iland, July 29, 1845. Early in his life the family removed to Brooklyn, New York, where he attended the public schools, and in 1862 entered a machine shop, where he was employed for several years before beginning his professional training at the Rensselaer Polytechnic Institute, from which he was graduated with the degree of Civil Engineer in 1868. This practical and theoretical training, with a capacity for persistent and faithful work, made him a resourceful man who could readily adapt himself to any conditions. Immediately after graduation he was employed in the development of Prospect Park, Brooklyn. He took part in bilding the first elevated railroad in New York City, and taught mathematics in the evening course at Cooper Union, and in 1870, became a member of the engineering staff of Cooper, Hewitt & Co. In 1871 he went to Peru, where he was engaged for four years on the difficult work of locating and construct-

OTHNIEL FOSTER NICHOLS.

ing the Chimbote & Huares and the Lima & Oroya Railways. Returning to this country in 1875 he became Assistant Engineer and Superintendent of the Edgemoor Bridge Company in the contract of that Company for the bilding of the Sixth Avenue Elevated Railway in New York. Owing to delays in this work caused by injunctions he joined the engineering staff of the Department of Parks, which had charge of the work of developing the annexed district, now the Boro of the Bronx. In 1878 he again went to South America as Resident Engineer of the Madeira & Mamore Railroad in Brazil. This project ended in disaster, and Mr. Nichols was obliged to go to London in connection with litigation growing out of it. In 1879 he became Assistant Engineer in the bridge shops of the New Jersey Steel & Iron Co., and in 1882 he became Resident Engineer on the Louisville & Nashville bridge across the Ohio River at Henderson, Kentucky. Upon the completion of this structure in 1886 be became Chief Engineer of the water-works of Westerly, Rhode Island, but after a short time he resigned to again take part in the development of the Elevated Railway system of New York, this time as Principal Assistant Engineer of the Suburban Rapid Transit Company, in the bilding of what is now the Third Avenue line in the Boro of the Bronx. In 1888 he became Chief Engineer of the Brooklyn Elevated Railroad Co., in which capacity he designed and bilt a large part of the elevated lines belonging to that company, while in 1892 he became General Manager of the Company. When the "New East River Bridge Commission" was organized in 1895, and Mr. Leffert L. Buck became Chief Engineer, Mr. Nichols was appointed Principal Assistant Engineer, and with this great structure, now known as the Williamsburg Bridge, he was closely identified from its beginning. In 1904 he became Chief Engineer of the Department of Bridges, which office he held for two years, and from 1906 until the abrupt end of his life he was Consulting Engineer of the same department. He was therefore closely identified with the designing and construction of all the great bridges across the East River, except the Brooklyn Bridge.

As this brief outline will show, Mr. Nichols' professional life was one of unusual activity, and while his experience was varied, his time and energy were devoted chiefly to structural work, and during his later years to some of the world's greatest bridges.

Mr. Nichols showed keen interest and took an activ part in professional organizations other than this Society. He was a member of the American Society of Civil Engineers since 1876 and was a director of the Society in 1892 and 1893. He became a member of the Institution of Civil Engineers of Great Britain in 1889, and in 1897 he was awarded the Telford premium by that Society for his paper on elevated railroads. He was a member of the American Society of Mechanical Engineers since 1896, a member of the Brooklyn Engineers' Club and its President in 1904. He was at the time of his death and for some years previously, President of the Engineering Department of the Brooklyn Institute of Arts and Sciences. He was also a member of the Engineers' Club of New York, of the Crescent Athletic Club, and of the Municipal Club of Brooklyn, a trustee of the Polytechnic Institute of Brooklyn, and a member of the Vestry of St. Luke's P. E. Church of Brooklyn. He was always activ in the Alumni Association of the Rensselaer Polytechnic Institute, and in 1895 delivered the address to the graduating class of that institution.

Well read in the best literature and an observant traveler, he was a forceful writer and speaker, and as a companion he was entertaining and delightful, with a great fund of anecdote and reminiscence drawn from extensiv travel and large acquaintance. But men of great professional attainments and of mental power are often lacking in those human qualities which make them loved as well as honored. Such qualities Mr. Nichols possest in an unusual degree. A keen sense of honor in his business and professional relations, an unassumed pleasure in the success of his friends and a warm sympathy in their reverses, a readiness to help those who needed assistance, not only by advice and good counsel drawn from his broad experience, but by giving of his substance, an unswerving loyalty to his friends which did not stop to consider his own personal interests—these are the qualities which made for him a host of friends, each one of whom felt a deep sense of personal loss when they heard of his untimely death.

It is not often that a man of mature years who has attained high professional standing shows a live interest in young men just beginning their life work. Many students and young engineers found in Mr. Nichols a ready, sympathetic and patient listener to

HENRY GEORGE HANSEN.

JOHN OWEN.

whom they could confide their perplexities and their disappointments, their hopes and ambitions without danger of cynical comment or caustic criticism.

His activ, useful, unselfish life, full of buoyant hope, and enriched by a rare capacity for the enjoyment of friendship and association with his fellows, came to its close without waning of power or impairment of vigor, and left a fine example of honor, loyalty and rectitude.

HENRY GEORGE HANSEN.

Henry George Hansen, member of the Municipal Engineers, died at his home in Brooklyn on July 28, 1908.

He was born in New York City on the twenty-third of July, 1887, and was educated in Public School No. 72 of Brooklyn, from which he graduated in 1902. During the following year he was engaged in the office of Mr. De Witt C. Reid, of New York City, in the real estate business. It was during this time that he commenced to study Civil Engineering, taking a course at the Correspondence School of Scranton, Pa. On leaving Mr. Reid's employ, he was engaged by the firm of Meserole & Middleton, Civil Engineers and City Surveyors of Brooklyn, as a rodman on general engineering work, which position he held till in 1904 he entered the city service as an axeman, with the Aqueduct Commissioners. He was assigned to the Engineering Corps at Katonah, N. Y., which was at that time engaged on the construction of the Cross River Reservoir. He was promoted in 1906 to the position of rodman and to that of leveler in 1907, which position he held at the time of his death.

Ambitious to rise in his chosen profession, he obtained a transfer to the main office of the Aqueduct Commissioners in New York City, where for the last year of his service he was employed on calculations and designs of various important works. During this time he was also a student in the evening courses in civil engineering at the Brooklyn Polytechnic Institute and had completed the studies of the first year.

He was a careful and accurate workman, conscientious and faithful in the discharge of his duties; he had the confidence of his employers and the good will of all who knew him.

JOHN OWEN.

John Owen died at his home in New York City on January 18, 1908, at the age of seventy-eight years.

He was born on September 9, 1829, in the City of Limerick, Ireland. About the year 1850 he came to this country and settled in New York City, where he was educated in the New York University.

He fought in the Civil War under Col. Lewis Benedict, and attained the rank of Captain.

He was a charter member of the Municipal Engineers, and at the time of his death was employed in the Topographical Bureau, Boro of the Bronx.

INFORMATION.

MEETINGS.—Regular meetings are held in the Engineering Societies Bilding, No. 29 West 39th Street, Manhattan, on the fourth Wednesday of each month at 8:15 P. M., except in June, July and August. The Annual Meeting is held on the fourth Wednesday in January.

LIBRARY.—The Society rooms and library are open every day and evening, including Sundays and holidays.

Members of the Society and all who feel an interest in the maintenance of a technical reference library, devoted more especially to the subject of municipal engineering, are askt to donate engineering books, reports, specifications, maps, plans, and fotografs.

PROCEDINGS.—The Society issues one volume of PROCEDINGS each year, usually in May. It contains all of the papers presented during the preceding year, the annual address of the President, the final reports of special committees on professional subjects, descriptions of the works visited by the Society, and the speeches delivered at the annual banquet which are of permanent value.

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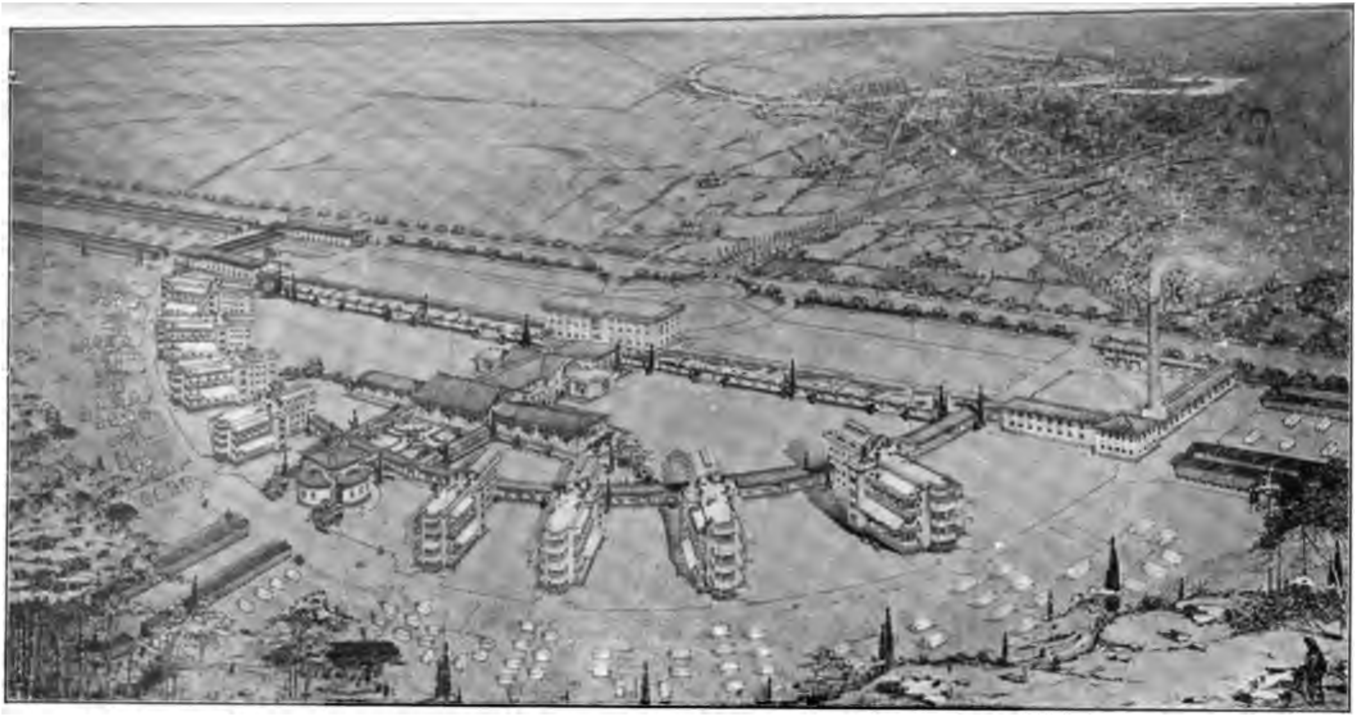

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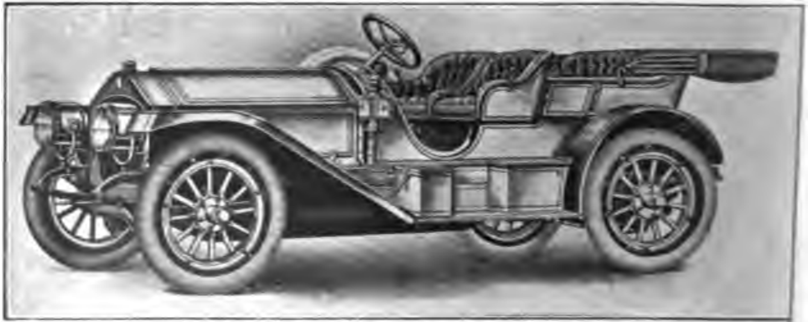

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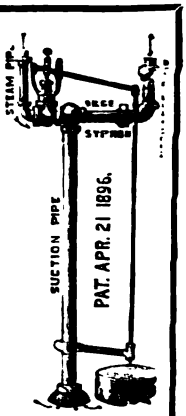

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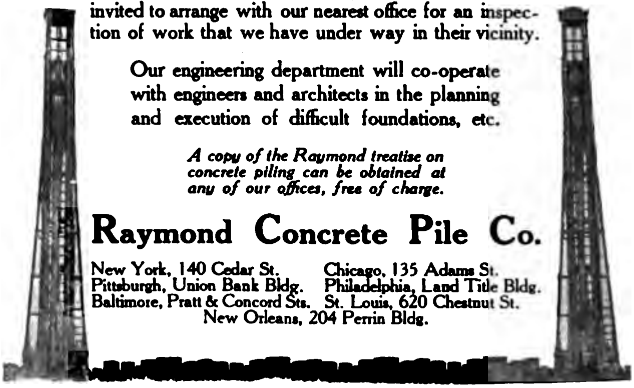

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